PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. V. 1864–65. No. 67.

Monday, 20th February 1865.

Sir DAVID BREWSTER, President, in the Chair.

The following Communications were read :—

1. Experimental Inquiry into the Laws of Conduction of Heat in Bars. Part II.—On the Conductivity of Wrought Iron, deduced from the Experiments of 1851. By Principal Forbes.

This is a sequel to a paper read 28th April 1862 (See "Proceedings," vol. iv. p. 607), and contains the results of the complete reduction of the observations on the conductivity of iron, by the application of the method there described. The thermometric readings are now rigorously corrected for scale errors, and for the difference of temperature between the bulb and the stem.

The methods of reduction, consisting of a combination of calculation and graphical projection, are the same as have been described in the first part of the paper. But the whole has beeen executed with minute attention to accuracy, and the avoidance of error of every kind.

Three cases are distinguished in the experiments and reductions, each complete in itself.

In Case I. a wrought-iron bar, fully 8 feet long and 1¼ inch square, heated at one end, had its temperature observed at different points. The surface was moderately polished.

In Case II. the same bar was employed in a similar way, except that the surface was covered with paper, by which the superficial radiation was greatly increased.

In Case III. an iron bar, one inch square, was used. The iron was from a different manufactory. The surface was moderately polished.

The two first cases correspond to those worked out in the former paper. ("Transactions," vol. xxiii. p. 145. "Proceedings," vol. iv. p. 609.) The results obtained in the present paper, after all corrections are applied, differ but slightly from those previously given. The conductivities deduced from the two first cases coincide with one another remarkably well, although the data are perfectly distinct. In Case III., that of the thin bar, the numerical values of the conductivity are considerably smaller than in the former instances, which is attributed to the different quality of the iron. In all the cases the conductivity diminishes as the temperature increases, and diminishes more rapidly in the lower part of the scale of temperature. The following numbers will be found (for Cases I. and II.) to be nearly identical at 0° and 150° with those previously published from less accurate data :—

Temperature, Centigrade.	Conductivity of Wrought Iron.			
	Units, the Foot, Minute, and Cent. Degree.		Units, the Centimètre, Minute, and Cent. Degree.	
	Cases I. and II.	Case III.	Cases I. and II.	Case III.
0°	·01337	·00992	12·42	9·21
50	·01144	·00904	10·63	8·37
100	·01012	·00835	9·40	7·76
150	·00934	·00795	8·68	7·38
200	·00876	·00764	8·14	7·10
250	·00826	·00736	7·67	6·84

2. On the Chemical Composition of the Waters of the Beauly, Inverness, and Moray Firths. By Dr Stevenson Macadam.

These three firths denote different parts of an arm of the sea which has two constrictions;—one between Craigton Point and Longman Point, and the other between Fort George and the

Chanonry Point. The upper part is known as the Beauly Firth, the intermediate portion as the Inverness Firth, and the outer part as the Moray Firth. Two rivers discharge their contents into this arm of the sea; the Beauly River, which flows in at the head of the Beauly Firth, and the River Ness, which joins at the head of the Inverness Firth. The waters of those rivers are comparatively free from saline matter, as during the dry season of the summer of 1863 the water of the Ness contained only 2·48 grains of saline matter dissolved in the imperial gallon, and the water of the Beauly only yielded 3·76 grains of saline matter. Besides these sources of fresh water, there are numerous burns which convey water, the composition of which is not essentially different from that of the Rivers Ness and Beauly.

Whilst the fresh water flows in at the upper parts, there is sea water rolling in and out at the lower part during every flood and ebb-tide, and in quantity sufficient to give rise to tides of the average height of eleven feet at certain parts, as at the narrowed channel connecting the Firths of Beauly and Inverness.

The special object of inquiry was to learn the influence of the fresh water upon the salt water, and the examination was restricted to the determination of three points:—

1*st*, The specific gravity or density of the water, as compared with distilled water, taken as 1000· at 60° Fahr.

2*d*, The total amount of saline matter dissolved in 1000 parts of the water collected at different stations; and

3*d*, The proportion of chlorine present in the various samples of water.

The principal compound of chlorine present in sea water is the chloride of sodium (common salt), and there are smaller proportions of chloride of magnesium and chloride of potassium; but, in an inquiry as to the relative saltness of samples of water from the same locality, it is sufficient to determine the amount of chlorine, and the calculation of chlorine into chloride of sodium affords the most convenient method of recognising the relative amount of fresh water which has commingled with the sea water.

The samples of water employed in these investigations were generally collected from a depth of three feet from the surface, but other samples were taken from the surface, and from a depth of six feet.

In reviewing the results of the determination of the specific gravities of the samples of water, it was observed that the fresh water supplied by the Ness and Beauly Rivers possesses the mean specific gravity of 1000·44; and the strongest sea water—viz., that of Burghead—shows a specific gravity of 1025·13. The many samples of water collected from the Firth of Inverness have a specific gravity which is considerably beyond the mean of fresh and salt water, and in the majority of instances closely approaches the specific gravity of the sea water taken off Burghead, and which is undoubtedly sea.

The results of the determination of the respective amounts of saline matter dissolved in the various waters entirely corroborates the conclusions arrived at from the consideration of the specific gravities,—viz., that each sample of water, as collected from the Firth of Inverness, is decidedly more salt than fresh, and in most instances the water is practically the strength of sea water. The lowest proportion of saline matter in the water of the Firth of Inverness is nearly eight hundred times the quantity found in the water of the River Ness.

The relative amount of chloride of sodium, as indicated by the proportion of chlorine in the waters from the Rivers Ness and Beauly, is so minute that it only amounts to about half a grain of chloride of sodium in the imperial gallon; whilst the lowest proportion of chloride of sodium (calculated from the chlorine) which is present in the water of the Firth of Inverness is equal to 1574 grains in the imperial gallon.

The water, therefore, obtained from any part of the Firth of Inverness, contains more than two thousand times the quantity of chloride of sodium, in a given volume or weight, than that which is present in the waters of the Ness and Beauly. In this vast increase in the proportional amount of common salt, there is the strongest corroboration of the greater prevalence of salt water in the Firth of Inverness; and, judging alike from the specific gravity, the total amount of saline matter dissolved in the water, and the large proportion of common salt, there can be no doubt that the Firth of Inverness is sea, and that it will be found by naturalists to afford to marine flora and fauna all the required strength and chemical properties so essential for the unimpaired growth, de-

velopment, and sustained life of marine vegetable and animal organisms.

3. On Hemiopsy, or Half Vision. By Sir David Brewster, K.H., F.R.S.

After describing the phenomena of hemiopsy, as observed by Dr Wollaston, M. Arago, and Mr Tyrrell, the author remarked that no attempt was made by these writers to ascertain the optical condition of the eye when it is said to be half blind, or to determine the locality and immediate cause of the complaint. Having experienced several attacks of hemiopsy, unaccompanied with any affections of the head or stomach, the author found that there was no insensibility to light, but merely an insensibility to the lines and shades of the object which disappeared. This insensibility commenced in both eyes, a little to the left of the *foramen centrale*, and extended itself irregularly to the margin of the retina on the left side. The parts of an object, or the letters of a word which disappear, are as bright as the ground around them, and are *white* if the ground is *white*, and always of the colour of the ground, so that the light of the ground has irradiated into the dark lines or shades of the picture on the retina, a phenomenon which can be produced in a sound eye by oblique vision.* This species of irradiation, however, is merely a local and temporary paralysis of the retina by the continued action of light upon the same part of it; but in hemiopsy, the irradiation is produced by the pressure of the blood-vessels, which may arise from various causes,—from the mere fatigue of the eye after long reading or exposure to bright light, or from affections of the head or stomach. That this pressure of the blood-vessels was the cause of the hemiopsy studied by the author, was proved by his going accidentally into a dark room while under its influence, when he was surprised to observe that all the parts of the retina which were affected were slightly luminous—an effect invariably produced by pressure upon that membrane.

* Letters on Natural Magic. Letter II. p. 13.

4. On the Tertiary Coals of New Zealand. By W. Lauder Lindsay, M.D., F.L.S., Honorary Fellow of the Philosophical Institute of Canterbury, New Zealand.

In 1861–62 the author visited and examined several of the Tertiary coal-measures of New Zealand; and the paper, of which this is an abstract, contains, or consists of, an epitome of his observations thereon. The collections of specimens made during his excursions, with relative maps and other illustrations, were exhibited to the Society at their Conversazione of 25th February 1863. A suite of coal specimens was submitted to chemical analysis by Professor Murray Thomson, the results of which are included in the paper.

The Tertiary coals of *Otago* are described: as being typical or representative of those of the other New Zealand provinces. Their characters or qualities are contrasted with those of the

1. *Tertiary Coals* of Auckland and Nelson, New Zealand.
2. *Tertiary Coals* of Europe.
   Glanzkohle of Germany.
   Brown Coals, or *Lignites*, of
      a. The Danube, Hungary, and Transylvania.
      b. Bohemia and the Rhine.
      c. Bovey-Tracey, Devonshire.
   Surturbrand of Iceland.
3. *Mesozoic and Palæozoic Coals* of Canterbury and Nelson, New Zealand.
4. *Palæozoic Coals* of New South Wales and Britain.

I. *Topography and Extent.*—Tertiary coal deposits occur more or less abundantly in most of the New Zealand provinces; especially, however, in Otago, Nelson, Canterbury, and Auckland. Occasionally they form belts extending for great distances, sometimes as much as fifty to one hundred miles, along sea-coasts or river banks. More generally, they are localised in isolated or circumscribed inland basins. Usually they occupy plains or valleys at low elevations. Sometimes, however, they are to be found at heights of several hundred, or even thousand, feet on the flanks of hills.

II. *Origin of the Coal.*—In different localities, and under different circumstances, it has at one time, apparently, consisted of *drift* wood and leaves; of *peat* bog, marsh, littoral or *forest* vegetation submerged *in situ* and subsequently re-elevated; or of *marine* vegetation (kelp) subsequently elevated. It has been found mainly in ancient lakes, estuaries, bays, fjords, coasts, or seas. Its associated strata present frequently, if not usually, alternations of *marine* (shell and kelp beds) with *terrestrial* deposits (dicotyledonous leaf or fern beds); indicating the occurrence of repeated and irregular oscillations of the relative levels of land and water during their deposition.

III. *Stratigraphical Relations.*—The best class of coals is referable to the *Lower* or *older* group of the Tertiary system; belonging, however, to different ages in this group.

Lignites, *jet*, and *fossilised wood* occur also in all the newer or superjacent Tertiaries, as well as the post-tertiary strata; while *drift wood* and *submerged forests* may be seen in process of fossilisation at the present day.

Not unfrequently the coal-beds rest immediately on the fundamental rock of the country, which is usually metamorphic slate, (probably of Silurian age), though sometimes granite.

The coal strata are frequently disturbed by eruptive or intrusive *Trappean* rocks of Newer Tertiary age, which sometimes tilt them up vertically, or throw them completely over. They are pierced likewise by *Trap-dykes*, and characterised by faults or dislocations resembling—save, perhaps, as to the scale on which they occur,—those of our own Palæozoic coal-measures. These Traps sometimes coke or cinder the immediately adjacent coal; more frequently, perhaps, the lithological character of the latter is unaffected.

IV. *Associated Strata*—

a. Conglomerates (locally known as "gravels" or "cements"), usually coarse and quartzose; frequently of a plum-pudding stone character; generally ferruginous; passing into

b. Grits, which again graduate into *sandstones*. Some of the latter are sufficiently hard and pure to be useful

building stones. Occasionally they are *carbonaceous;* or they are impregnated, or intermixed, with *magnetic iron.*

c. *Clays*, frequently arenaceous or carbonaceous, or both; sometimes ferruginous; occasionally white and pure. They include every variety of *kaolin*, plastic or *potter's*, *pipe*, *fire*, and *brick* clays; and *ochres* or ferruginous earths; many of which are suitable for utilisation in the industrial arts.

d. *Shales*, also generally arenaceous or carbonaceous, or both; sometimes richly fossiliferous, containing especially *leaves* (of exogenous trees and ferns) beautifully preserved.

The coal-beds are frequently directly overlaid or roofed by Newer or upper Tertiary strata; consisting usually of various conglomerates or gravels, sands and clays.

V. *Contained Minerals*—

a. Various *Fossil Resins*, similar to those which occur in the brown coals of Germany. To the settlers they are generically known as *Kauri gum*, and are considered identical with the fossil resin so called in the North Island —which is generally regarded as the produce of the existing *Dammara australis* Lambert (N. O. *Coniferæ*). They include *Retinite* and *Ozokerite.*

b. *Iron Pyrites* (including *Marcasite*); *Sulphate of Iron;* *Clay Ironstone* nodules.

c. *Sulphur*, generally impregnating sands or sandstones; clays or mudstones.

d. *Quartz*, as an impurity.

e. *Jet;* and vegetable débris in the form of *Mineral Charcoal.*

VI. *Lithological or Physical Characters.*—Hand-specimens exhibit all gradations between *Lignite*, *Brown Coal*, *Pitch Coal*, *Cannel* or *Parrot*, and *Common British Domestic*, *Coal*. Their texture, fracture, and lustre consequently vary extremely. Generally they are earthy and massive; occasionally laminated; splinter readily on exposure; do not cake in burning; *colour* and *streak*, brown to black; *specific*

gravity, 1250 to 1300; *ash* generally light like that of wood; colour various shades of white, gray or buff; *coke* dull to iridescent.

VII. *Chemical Constitution.*—The following, which is the mean (in round numbers) of numerous analyses, by various chemists, of the Tertiary coals of different parts of the New Zealand Islands, may be held to represent their average composition:—

a. Proximate Constituents—

Coke,	45	per cent.
Carbon in coke (or fixed carbon),	40	,,
Volatile matter (hydro-carbons),	45	,,
Ash,	6	,,
(Components—Silica, alumina, iron, magnesia, and lime.)		
Water of constitution,	15	,,
Gas, cubic feet per ton,	4000	
Oil, gallons per ton,	15	

b. Ultimate Elements—

Carbon,	60	per cent.
Hydrogen,	5	,,
Nitrogen,	1	,,
Oxygen,	20	,,
Sulphur,	2	,,

VIII. *Commercial Value.*—The following are defects in most, if not all, of the Tertiary coals of New Zealand:—

a. Proportion of *water* or moisture they contain: frequently 20 to 30 per cent.

b. Comparatively large amount of *ash.*

c. Comparatively large amount of *sulphur* (in pyrites), giving rise to a disagreeable odour during combustion.

d. Occasional presence of *lime,* which gives the quality of *fusibility.*

e. Tendency to fall to dust or "small" on exposure or desiccation.

f. Burn well only when associated with some more inflammable fuel, such as wood, peat, or Palæozoic coal.

Nevertheless, *in the absence, or with a mixture, of fuel of a superior kind*, this class of coal is, or may be, used as a domestic fuel,

as well as in various branches of local manufacture, such as brick and pottery making, and metallurgic processes. Its use is, and is likely to continue, strictly *local.* At present it is employed as a domestic fuel, mostly on the gold-fields, where it abounds, and where fuel of a better class is scarce, if at all to be had; or, intermixed with better fuel, by the poorer classes in large towns. It cannot compete, either as a domestic, steam, or other fuel, with New South Wales or British coals (Palæozoic), which uniformly command a higher price, and occupy a superior position, in all the New Zealand markets.

In all the large towns of New Zealand, especially in Dunedin, Christchurch, Nelson, and Auckland, there is now a comparatively good supply of both local and foreign coals. The market prices of the former vary according as they are delivered at the pit-mouth or in the towns; and those of the latter as they are delivered in the towns, or from the ships' sides in harbours or roadsteads.

The market prices of New Zealand Tertiary coals vary from 7s. 6d. to 35s.—average, 10s. to 15s.—per ton, delivered at the pit; and 40s. to 50s.—average, 45s.—delivered in towns. Those of Newcastle (New South Wales), or Newcastle (English) coal, range from 40s. to 80s. per ton, according as they are delivered from the ship or in town.

IX. *Produce of the Collieries.*—As yet *labour* is limited and dear, and *machinery* defective; so that the highest yield at present is 100 to 150 tons per week (Fairfield Colliery, about six miles southward of Dunedin, Otago); the average elsewhere being 50 to 100 tons.

X. *Flora of the Coal Measures.*—Consists chiefly of the *wood* and *leaves* of *exogenous trees*, probably in great measure *coniferous;* and of *ferns.* The leaves include those of species of the following genera:—

Fagus,	*Myrtifolium,*
Loranthophyllum,	*Phyllitis.*

The general Tertiary flora comprises—

a. The *wood* of various *conifers*, perhaps including the *Kauri pine*, which still exists, though within a limited area, in

the North Island; and of other *exogenous* trees:—frequently *silicified* like the fossil wood of Antigua.

b. The *leaves* of various exogenous trees of the orders apparently of *Lauraceæ* and *Cycadaceæ* (genera allied to *Laurus* and *Zamia*)—frequently, like the wood, beautifully silicified and preserved; of *endogenous* trees, chiefly of the family *Palmaceæ;* and of arborescent or large-fronded *ferns.*

Most of the fossil plants of the New Zealand Tertiaries are apparently *extinct* species; but, as in the parallel case of the *fauna*, a few may be referable to *living forms.*

XI. *Fauna of the Coal Measures.*—Mostly *marine*, including—

a. Cetaceæ; bones.

b. Fish of the *shark* family (teeth): genera *Lamna, Carcharias, Oxyrhina.*

c. Echinoderms: Brissus, Schizaster, Hemipatagus.

d. Mollusca: species of the following genera:—

Ostrea,	*Turbo,*
Pecten,	*Crassatella,*
Terebratula,	*Dentalium,*
Natica,	*Struthiolaria,*
Voluta,	*Scalaria,*
Purpura,	*Waldheimia.*
Trochita,	

The general Tertiary Fauna includes in addition:—

Cardium,	*Cyrena*	fresh-water.
Cucullæa,	*Melania*	
Mytilus,		

While the major portion are *extinct* species, some are identical with *existing forms.*

XII. *Fossilisation of Vegetation at the present day.*—Instances are given of *Tree Beds* at various depths below the soil, and at various elevations on the mountains: of the fossilisation of *drift-wood,* leaves and seeds in swamp clays: of the *submergence* of Kauri or other *orests*—that are being, or have been, converted into Lignite on the *western* coasts (which are undergoing a process of *subsidence*):

and of the overwhelming of existing forests by sea-sand on the *eastern* coasts (which exhibit phenomena of *elevation*).

Within an area of a few hundred yards on the Greenisland coast of Otago, the sand-dunes may be seen encroaching on the forest, which consists mainly of gigantic *conifers*: of other *exogenous* trees of the natural orders—

Myrtaceæ,	*Violarieæ,*
Araliaceæ,	*Pittosporeæ,*
Leguminosæ,	*Malvaceæ,*
Onagrariæ,	*Tiliaceæ,*
Magnoliaceæ,	*Corneæ :*

of palm-like and shrubby *Liliaceæ ;* and of arborescent *Ferns :* while they are also covering in marshes and lagoons, whose vegetation consists chiefly of littoral *Grasses* and *Cyperaceæ : fresh-water aquatics ; salt-marsh plants :* and *marine Algæ.*

The following Donations were laid on the table :—

Bulletin de L'Académie Royale des Sciences, des Lettres, et des Beaux-Arts de Belgique, No. 12. Bruxelles, 1864. 8vo.—*From the Academy.*

Natuurkundige Verhandelingen van de Hollandsche Maatschappij der Wetenschappen te Haarlem. XIX[e] Deel, XXI[e] Deel, 1[e] Stuk. 4to. Haarlem, 1864.—*From the Society.*

Sitzungsberichte der Konigl. Bayer. Akademie der Wissenschaften zu Munchen, 1864. II., Heft 2. Munchen, 1864. 8vo.—*From the Academy.*

Report of the Proceedings of the Geological and Polytechnic Society of the West Riding of Yorkshire for 1863–64. 8vo. Leeds, 1864.—*From the Society.*

On the Early History of Leeds. By Thomas Wright, Esq., M.A. 8vo. Leeds, 1864.—*From the same.*

Forty-fourth Report of the Leeds Philosophical and Literary Society. 8vo. Leeds, 1864.—*From the Society.*

Thoughts on the Influence of Ether in the Solar System, its relations to the Zodiacal Light, Comets, the Seasons, and periodical Shooting Stars. By Alexander Wilcocks, M.D. 4to. Philadelphia, 1864.—*From the Author.*

Die Fossilen Mollusken des Tertiær-Beckens von Wien. Von Dr M. Hörnes. Band II. 5, 6. 4to. Wien, 1865.—*From the Author.*

Monthly Notices of the Royal Astronomical Society, Vol. XXV. No. 3. 8vo. London, 1865.—*From the Society.*

Letter from John Davy, M.D., F.R.S., addressed to the editors of the Philosophical Magazine, in reply to a certain charge made by Charles Babbage, Esq., F.R.S., against the late Sir Humphry Davy, when President of the Royal Society. 8vo. —*From Dr Davy.*

Proceedings of the Natural History Society of Dublin for 1863–64. Vol. IV. Part II. 8vo. Dublin, 1865.—*From the Society.*

The American Journal of Science and Arts, Vol. XXXIX. No. 115. 8vo. New Haven, 1865.—*From the Editors.*

The Quarterly Journal of the Geological Society, Vol. XXI. Part I. 8vo. London, 1865.—*From the Society.*

The Journal of the Linnean Society, Vol. VIII. No. 32, Botany. 8vo. London, 1865.—*From the Society.*

Reale Istituto Lombardo di Scienze e Lettere—Rendiconti—Classe di Scienze Matematiche e Naturali. Vol. I. Fasc. 7, 8. Classe di Lettere e Scienze Morale e Politiche. Vol. I. Fasc. 7. 8vo. Milano, 1864.—*From the Institute.*

Solenni Adunanze del Reale Istituto Lombardo di Scienze e Lettere, Adunanza del 7 Agosto 1864. 8vo. Milano, 1864. —*From the Institute.*

Journal of the Chemical Society, January 1865. 8vo. London, 1865.—*From the Society.*

Monday, 6th March 1865.

Sir DAVID BREWSTER, President, in the Chair.

1. On the World as a Dynamical and Immaterial World. By Robert S. Wyld, Edinburgh.

What is matter? has been the question of philosophy from the earliest times. The author of this paper referred to the specula-

tions of Thales and other philosophers of the Ionic school six hundred years before Christ, and to the more profound views of the Eleatic school, which had its origin about fifty years later, and the questioning which then arose regarding the reality of the knowledge given us by the senses.

Hume, by ingenious arguments, endeavoured to throw distrust on all human knowledge, and to show that we could neither prove the existence of power, the connection of cause and effect, nor the existence of an external world. Kant, roused by this, undertook to prove that the mind had certain judgments and beliefs, irrespective of those derived from our connection with the world. This set the German thinkers upon an exhaustive examination of mental phenomena, and led to the idealism so prevalent in German philosophy.

Disregarding, however, the extreme views of a numerous class of idealists, the question still remains open before us, What is matter?

The phenomena met with in prosecuting chemical science are frequently so marvellous and unexpected as to raise in the mind of an abstract thinker doubts as to the theory that the atoms with which he is dealing are material atoms. The idea of *matter* or *substance* implies to every man who considers it abstractly the possession of *certain qualities inherent in each substance.* This idea is found, however, to be the reverse of a true one. The most trifling difference in the proportions in which *substances* are combined frequently creates the most entire change of property. Witness the results of the various combinations of oxygen with carbon, with hydrogen, or with nitrogen, and witness the still more surprising animal and vegetable productions which result from the united combination of these four elements—the oils, the gums, the dies, the flesh, the vegetables, the medicines, the poisons,—in fact, nearly the entire catalogue of animal and vegetable products and principles with which we are acquainted. Quinine is composed of seventy atoms of these four elements, and so is strychnine, the only difference being that the poison has two atoms more of carbon, and two less of hydrogen, than the tonic. All such facts indicate that the ultimate elements and their combinations act dynamically, for they do not act according to the way we would expect *substances* to act.

Consider the atoms as matter, and all seems contradiction; consider them as forces, and the phenomena, we observe, become comparatively easy to understand or to conceive.

For example, the tissues of the animal frame are a nicely-balanced combination of elementary atoms. All animal and vegetable tissues are composed of clusters or groups of these atoms, and the nature of the grouping implies, as the organic chemist well knows, that these forces are held in comparatively feeble combination. What is flesh to-day is corruption to-morrow, resolving itself into new combinations. This is an essential condition, and without it nutrition, assimilation, and renovation would not be possible; for it is only where all is feebly held together that a ready transfer of the parts can be effected. If, then, we regard our bodies, and the substances we take into the stomach, as nicely balanced collocations of forces, we can understand how one group may nourish us, or become incorporated with our bodies, while another slightly different combination may dissolve or break up the forces binding the substance of the animal tissues together, or may stifle or may stimulate the movements of the nervous energy, or may completely paralyse the organ where this vital agent is generated.

The following seven considerations and facts, derived from physical science, lead us to the conclusion that matter does not exist:—

1*st*, All matter (if such an entity exists) acts external to itself. The sun acts on the earth, and the earth acts on the moon. The power of attraction between these large bodies, considered as a mechanical force, is enormous; and as we know of no material link between them which can explain so strange a fact, we are compelled to believe in the existence of this tremendous mechanical or physical force without a mechanical agent to produce it.

2*d*, It is evident, in like manner, that when chemical atoms act on each other, they act external to themselves. It is therefore here not matter which acts on matter, but force on force.

3*d*, It can be proved that no one portion of matter ever touches another. The elasticity of all substances proves this; and when it is objected to this argument that the ultimate parts of matter may be compressible, this objection is merely equivalent to saying that *their* parts may *come closer*, and that they are not absolutely close.

In gases the intervals between the atoms must be enormous, and yet, if the old theory of repulsion holds, the atoms still repel one another, even under the nearly fully exhausted receiver of an air-pump.

4th, A ray of light falling on a polished surface of coloured glass, or on a mahogany table, &c., is reflected without acquiring any of the colour of the body reflecting it. This proves that the action in reflection is external to the substance of the glass, and that the ray never touches the reflecting surface.

The fact with regard to light, that the angle of reflection is equal to the angle of incidence, and that there is no dispersion of the ray, owing to the necessary roughness of all artificially polished surfaces, is, as Sir John Herschel observes, in his article on light (Ency. Metr.), a proof that the ray never touches the surface, but is reflected at a certain distance from it.

5th, The passage of the *refracted ray* after it has passed through the band of force (where it is bent down towards the glass), and comes upon the partially rough substance of the glass, affords a strong proof that it does not encounter matter there to obstruct or scatter it, for it meets the surface at every conceivable angle, and yet the different parts of the ray pass through all the inequalities, preserving their direction parallel with one another. We must therefore regard the surface of the glass as merely the first line of centres of the atomic forces which constitute the substance of the glass, and which centres terminate again in the line of the lower surface of the glass.

6th, The free vibration of the ether in the densest bodies, such as the diamond, ruby, glass, water, and crystals, and the parallel direction of the luminiferous ray, is not reconcilable with the theory of transparent bodies being solid and natural bodies.

7th, Our inability to interrupt the attracting action of the magnet by the intervention of numerous plates of non-magnetic dense bodies, such as glass, copper, lead, pasteboard, &c., either singly or in combination, affords a strong presumption that all these substances interposed are composed not of solid matter, but of combinations of immaterial forces.

It is evident from the above facts and considerations that we never touch matter (even if it exists). And that we never see it is admitted alike by physiologists and metaphysicians, for vision is

merely a mental affection, called up by an impulse on the optic nerve made by the movements of the luminiferous ether, which, not the chair or table, but the forces existing and acting external to the chair or table, or other object, radiates off. Moreover, it is universally admitted that vision is only a mental affection, not corresponding to anything external to the mind.

Chemical atoms may therefore be regarded as circles of force without any nucleus or core of matter in them; for if the forces are the efficient parts, there is evidently no necessity to assume that an inert and useless part will exist within them. The law of Parsimony entirely justifies us in assuming this, and in discharging matter from the atom.

The universe in this light becomes a vast and glorious exhibition of *power*, acting and displayed according to those laws which have been impressed, and which laws and system we designate *the laws of nature.*

Sir John Leslie, in his Dissertation prefixed to the "Encyclopædia Britannica," seems to have no disfavour to Boscowich's "Theory of Dynamics," except that the material points are made mathematical points, and suggests that, in order to get over this prejudice, we may conceive the material centres "to have real dimensions, though *far smaller than any assigned measure.*"

Professor Forbes, in his Dissertation, expresses a difficulty in reconciling this theory to the law of *inertia.* This is probably a chief difficulty felt by most men, to conceive of inertia being possessed by immaterial bodies. But the difficulty is entirely imaginary, and arises from our habit of considering that *matter has inertia*, and conceiving that therefore nothing but matter can have it. It is evident we cannot declare what properties are incompatible with immaterial forces. Our proof that we must admit them to have *inertia* is this. Let us suppose a molecule of forces at rest; it evidently will not move *unless force is applied; a certain amount* of *force* is required *to give it a certain velocity.* If this be admitted, then it follows that if the molecule be increased 10, 100, or 1000 times *in mass*, it must necessarily require 10, 100, or 1000 times that force to produce the like velocity. So far, then, as we have analogy and argument to guide us, these immaterial bodies must have *inertia*, at least the mouth is shut against declaring that they cannot have it.

If a difficulty still remains in conceiving immaterial masses to

possess *inertia* or the feeling of ponderosity or immobility, the difficulty should vanish when it is kept in mind that all our perceptions of force are only *relative*, not *absolute*. If our living bodies, then, and the substance of all external objects, are of the same immaterial nature, we should not be surprised, but should rather expect, that the *inertia* of external objects should appear in proportion to their masses, and that it should also have a relation to the strength as well as the mass of our percipient bodies, all being composed of the same immaterial substance.

The great difficulty felt by those metaphysicians who believe in matter has always been regarding this *inert thing*, *matter*. Take away, say they, the qualities of colour, heat and cold, resistance or solidity, from any object, and an inert something remains to puzzle us. The author, on the contrary, holds that resistance or solidity constitutes matter. The difficulty felt by metaphysicians is thus avoided—namely, the necessity of conceiving a thing to exist without qualities.

There is another difficulty which besets the believer in matter. The human mind has always felt a difficulty—an apparent incongruity, almost approaching to a feeling of impossibility—when it conceives of a Being, whose essence is spiritual, creating a thing of a different essence from Himself, which matter is conceived to be. The ancient philosophers of Greece, feeling this, declared that matter was uncreated, and eternal. Spinosa, one of the acutest minds, felt also the same difficulty, and in his *Ethics* he lays it down as an axiom of reason that "the knowledge of an effect (the world, for instance) depends on the knowledge of the cause, and things that have nothing in common with each other (matter and spirit) cannot be understood by means of each other." Hence the one cannot be the cause of the other. We state this principally to show how extensively the difficulty has been felt of conceiving the existence of two different essences in nature.

Recent discoveries have established that heat is mechanical force, the two being mutually convertible without loss. The attraction of gravity and chemical attractions and repulsions are all the same physical force, and the entire external world is nothing but a manifestation of it,—a simple and grand conception, and one which enters the domain alike of physics, of speculative philosophy, and

of theology, and which in all of these sciences is equally important. It represents the external world and its Creator as possessed of one immaterial and *spiritual* essence—*power* and *intelligence* being the attributes of the Creator, and *power subordinate and sustained the characteristic of the creation.*

The objection to a system of pure dynamics will probably be this. It will be said forces cannot exist except as the *properties of matter.* The belief in the necessity of matter is all but universal. This arises, we think, from a law of the mind, which when it reflects on *any thing as existing* immediately, and of necessity, assigns a cause for its existence. The generality are satisfied to regard the *properties perceived as constituting the thing or object.* The object is thus a hard or soft, a black or white, or coloured thing. The man of science applies his mind to the consideration of the *properties*, and afterwards to the consideration of the thing itself, as if they were different entities, and he thus assigns matter as the *cause* of the properties he observes. The author also believes in a cause for the forces of which he has spoken; but as he has not matter to fall back on, he is compelled to assign as the *cause* that Being who is the centre of all power and wisdom, and who manifests these attributes to his creatures in the vast and complex arrangements of a dynamical universe.

The tendency of speculative philosophy has been to run into idealism. This has been its fate in Germany, and it is to be feared it may come to the same conclusion in Scotland. The author would deeply deplore such an end to our boasted Scottish philosophy. The ultimate foundation of all reality has been admitted by nearly every philosopher to be the Supreme Being. If, then, the theory propounded should assist abler hands in establishing realism directly on this foundation, the author would feel in no ordinary degree gratified and rewarded.

2. On the *Nudibranchiate Mollusca* of St Andrews; *Edwardsia;* and the Polyps of *Alcyonium digitatum.* By W. C. M'Intosh, M.D., F.L.S. Communicated by Professor Allman. (Accompanied by various Drawings.)

The Nudibranchs owe their prominence in British zoology to the

late Dr Johnston of Berwick, and to the splendid monograph of Messrs Alder and Hancock.

Inhabitants for the most part of the laminarian and littoral zones, the rocks and rock-pools, by minute and continued search, produced the greater number of those met with at St Andrews, the few others being procured from fishing-boats and débris of storms. Almost all require to be sought for with care, and generally escape superficial notice altogether. Most have been kept for a longer or shorter period in confinement, and some are living even now, though with greatly diminished bodies, and less brilliant tints, the results of insufficient food and other unfavourable circumstances.

Their favourite haunts are under stones in pools, and the more undisturbed these look, the better chance is there of securing fine specimens. The upturned surface of the stone, however, should be immersed an inch or two under the clear water, so as to float out the branches of the zoophytes and the branchiæ of the Eolids. The fondness of the smaller forms for surfaces covered with Sertularidæ is also seen in the case of storms, where the richest fields are the broad blades of the Laminariæ that are covered with *Laomedea geniculata* and *gelatinosa.*

The species met with at St Andrews will be given in the order in which they occur in the "Monograph" above-mentioned, with such remarks appended to each as may seem necessary or new.

The most plentiful Nudibranch here, as elsewhere, is *Doris tuberculata,* which occurs in all sorts of places amongst the rocks at low water. In storms, many are found on the west sands in the intricate hollows of large masses of *Halichondria panicea,* a situation affording them both food and shelter. Some, found under large stones in pools, were unusually flattened and rounded, like gigantic Lamellariæ: such are not gaily tinted. Most of the specimens, especially those of large size, had some of the parasites described by Alder and Hancock under the name of Ergasilus, which sported over their branchiæ and other organs with wonderful agility. Messrs Alder and Hancock state that they are colourless, but in most cases these had a pure white cross on the back, and some were pinkish. The largest Doris measured fully 4¾ inches. Their food, as usual, is *Halichondria panicea.*

Doris Johnstoni is somewhat scarce, and generally in company with the former under stones between tide-marks. This species does not sport in tint. It is an active animal in confinement. The same species of Ergasilus occurs on this Doris as on the former. Largest specimen, 2½ inches.

Doris repanda is one very commonly found at all seasons amongst the rocks. The largest specimens are often of a dusky yellow tint. Many had the border of the cloak injured, as if a portion had been eaten out. It is very tenacious of life in captivity. Two kept for some time in a vessel along with a little *Corallina officinalis* deposited their ova; and this being one of the few species that Messrs Alder and Hancock had not observed at the breeding season, nor yet succeeded in obtaining its spawn, a more detailed account will be given.

On the 10th of November, the two were observed *in coitu*, and apparently in a state of excitement, elevating the cloak all round the margin in a curiously frilled manner. They lie head to tail, but not very closely, and the intromittent organ is capable of great extension and distension, so that the animals are enabled to effect their purpose, even when one is lying at right angles to the head of the other. On the 12th they were both in process of depositing their spawn on the side of the glass. The coil is a simple one, attached by the edge, and sloped upwards and inwards. The eggs are very large and conspicuous.

In spawning, the body is shortened; the posterior edge of the cloak being doubled inwards, so as to press on the outer edge of the coil of ova. The upper (left) edge of the cloak is raised from the surface and arched in a graceful manner. The anterior border is spread out and flattened on the surface of the glass, and the fore part of the foot is likewise similarly fixed. In the centre of the coil of spawn, the foot was bent upon itself, causing a deep dimple, and this hollow remained although the animal changed its position. As the act of deposition proceeded, it glided the anterior (attached) extremity upwards, while the posterior (free) turned downwards, thus favouring the gradual exit of the coil. The anterior part of both foot and mantle constituted a broad pivot on which the animal revolved from right to left. The posterior border of the mantle did not always remain alone at the outer part of the coil, for by

and by the posterior part of the foot likewise projected, and the dimple in the centre became less marked, though still present.

Next day it had nearly completed two coils, and then, having diverged at an angle, left an interrupted row of ova in single file.

So far as observed, their stomachs contained only cells and granules.

Doris aspera.—Under stones in pools near low-water mark; not uncommon.

Doris bilamellata.—Abundant all the year round; occurring in swarms in March, and, according to Dr John Reid, in February also. They manifest a tendency to congregate together in a vessel, and often crawl out of the water. Their stomachs contain a greyish-brown mass of granules.

Doris pilosa.—Common; of all hues, and occasionally party-coloured. The same peculiar granular matter existed in the stomachs of this species, but with the addition of a greater number of larger granules and cell-like bodies; there was also a tendency to form bolus masses.

Of *Doris subquadrata*, only a single specimen occurred.

Goniodoris nodosa is a very common species, first found here by the late Rev. Dr Fleming, and afterwards by Dr John Reid. There is little to be met with at St Andrews in support of the statement of the able authors of the "Monograph"—in regard to the disappearance of the adult animal and the growth of the young; for the varying sizes occur throughout the entire year, fine full-grown specimens ($1\frac{1}{4}$ inch) being found in December as well as in March, April, and May. They are hardy in confinement.

Triopa claviger occurs now and then under stones, in situations seldom invaded by aught but the waves. The most striking fact in connection with this animal is the occurrence, in two out of three specimens, of crustacean parasites (Ergasili) similar in all respects to those found on the two first-mentioned species of Doris.

One of the most remarkable amongst the Nudibranchs, and at the same time comparatively rare, is met with in considerable abundance, viz., *Ægirus punctilucens.* Belying its generic name, it frequents the under surfaces of stones in pools, from low water

to above half tide mark, apparently delighting in dark surfaces whose tints closely resemble its own. They were met with several times in groups. *Æ. punctilucens* lives well in captivity, and it spawns in July.

Polycera quadrilineata was first found at St Andrews by Dr John Reid in the month of September. It is occasionally got after October storms, and at low-water mark during the same season. They also spawn at that time.

Polycera ocellata is gregarious amongst these rocks; very active in confinement; apparently phytivcrous. Spawns in September, and sometimes the ova are deposited on the surface of the water in an incomplete coil.

One young specimen of *Polycera Lessonii* occurred after an October storm on a laminarian blade covered with *L. geniculata.*

Ancula cristata is rather a common Nudibranch, living under stones in quiet pools between tide marks, sometimes in groups of three. The majority of the specimens are pale. They spawned in August.

Tritonia Hombergii comes occasionally from the deep-sea fishing. In the stomach of one, about 3½ inches long, were fragments of the usual food (*Alcyonium digitatum*), mixed with darker dêbris, possibly from Amphitrite tubes.

Tritonia plebeia, very abundant on *Alcyonium digitatum* (on which it probably feeds), cast on shore by storms, on corallines from deep-sea fishing, and procured by the dredge off the laminarian zone. Twice were full-grown specimens got in autumn, having a remarkable process on the left side, about the last branchial appendage; indeed, the tail seemed bifid.

Dendronotus arborescens generally comes from deep water in the fishing-boats, or from dêbris of storms. Dr John Reid first procured it at St Andrews. None were ever heard to emit the sounds mentioned by him and Dr Grant.

Doto fragilis.—Specimens occur on corallines from deep-sea fishing. They are rarer than the succeeding species, and generally larger.

Doto coronata.—Abundant in the same regions as the former and also under stones in rock pools. One showed a curious abnormality in the left dorsal tentacle.

Eolis papillosa occurs very plentifully during some years amongst the rocks, but is absent from its accustomed haunts during others, without apparent cause.

Supplying the place of the large *E. Drummondi* of the west coast, is the more beautiful and graceful *Eolis coronata*, which is occasionally met with near low-water mark. They sometimes devour portions of their own tails.

Eolis rufibranchialis appears amongst the rocks, and in débris of storms. The white granular streak down the tail is interrupted by pale papillæ. They are agile and restless in confinement, and do not scruple to devour a dead companion of any species.

Eolis olivacea is met with sparingly under large stones in rock pools, between tide marks. It is hardy.

One of the most plentiful species is *E. viridis*, a group of six or seven occasionally occurring under a stone, and smaller numbers more frequently. Of all the Eolides observed, this has the most prehensile tail. It is easily kept for many months, though it loses its tints.

Eolis Andreapolis, n. s.—*Body* half an inch long, ovate-oblong, of a pale-yellow or dull purplish hue, the latter chiefly marked at the sides; with the dorsum faintly granular, and brilliantly blotched over with large, elongated, bright orange-pink spots, which were quite absent from the tail. Some of these spots were in front of the dorsal tentacles—one at the anterior and outer aspect of each, and a very distinct mass at their junction. There are a few smaller orange spots at the sides below the branchiæ. *Dorsal tentacles* about twice as long as the oral, not much tapered, approximating at the base; tips pale amber, then a broad belt of reddish orange; a few white grains at either end of the orange. *Oral tentacles* short and blunt, capable of a spoon-like flattening; similarly tinted. *Branchiæ* elliptical or club-shaped, purple, pale at the base, and densest in colour next the reddish-orange cap at the tip. In one pale specimen, a waved central vessel was apparent. There appeared to be more than a dozen transverse rows. The structure of the tongue approached most nearly to *E. tricolor*. Found after storms, and at low water amongst the rocks.

Eolis Farrani.—At low water amongst the rocks, and on the beach after storms. Not uncommon.

Eolis exigua.—A number were found on *Laomedea geniculata* upon Laminarian blades, cast on shore by an October storm.

Eolis Robertianæ, n. s.—*Body* three-tenths of an inch long, rather stout, and of a prevailing orange-red hue; granular, with a few paler spots. *Dorsal tentacles* extremely attenuated, long, linear, smooth, orange-red. Eyes very distinct, set in a pale yellow space at the base of the tentacle posteriorly. *Oral tentacles* shorter, linear, similarly attenuated, orange red, and proceeding from the angles of the lip. *Branchiæ* thick, rather swollen, elongated, tipped with deep orange-red, which likewise passes down the sides; the base paler orange. They were incomplete in the specimen, but appeared to be set in nine or ten transverse rows, leaving a considerable space in the centre. The first row comes nearly as far forward as the dorsal tentacles. *Foot* orange yellow, rather suddenly tapering to a short tail. *Jaws* of a pale straw colour; lingual plates somewhat like those of *E. tricolor*, and stouter than in *E. Farrani*. From the border of the laminarian zone during a spring tide.

Note on the Polyps of Alcyonium digitatum.

The varied descriptions and figures of these common polyps probably arise from the changes which so readily ensue on removing them from their native sites in the usual manner. The figure given by Ellis,* though not accurate, shows a closer approach to the natural aspect of the tentacles than Dr Johnston's,† and the same may be said of Müller's.‡ Dr Johnston is correct enough in his description, so far as it relates to faded and sickly specimens brought from deep water by the fishermen. Sir J. G. Dalyell § is somewhat more exact in his description of the tentacula and general appearance, but his figure does not represent the polyps in perfection.

The most perfect specimens are got amongst the rocks at low water, under stones in pools. Small patches can be chipped off, adhering to a fragment of stone, without injury ; and taking one of these, three-fourths of an inch in diameter, it is found that the

* The Nat. Hist. of many Curious and Uncommon Zoophytes.
† British Zoophytes, p. 177. Plates xxxiv. and xxxiv*.
‡ Zool. Danica. Tab. lxxxi.
§ Rare and Remarkable Animals, &c., vol. ii. p. 176. Plate xlvii.

thickness of the film in contraction is not more than one-tenth of an inch. As the polyp contracts into its stellate aperture, its mouth gapes, apparently the more readily to give exit to the water in its interior. It presents the aspect of an octagon with hollow sides when about the level of its cell. Rows of spicula project from the corners towards the centre.

If further extended, the tentacula, their pinnæ, and the rows of spicula become more apparent; oral aperture dilated; outline of oral disc similarly octagonal, though much larger.

When still further extended, a coiling of the arms is frequently seen, like the circinate vernation of the ferns.

In a state of full expansion, the polyp is elongated and narrowed towards the head, measuring more than half an inch from the tips of the tentacula to the base. The tentacles can be stretched to more than twice the diameter of the oral disc, are narrow and tapering, and have the elongated pinnæ at each side; the tips are slightly opaque, probably from minute suckers. The tentacles are also roughened by minute spicula, which do not, however, go further than the base, where a pale, unspiculated portion occurs; below this the neck of the polyp is supplied with long spicula with tuberculated edges, arranged in an arrow-shaped manner. In those polyps which are best expanded, the diameter of the oral disc is smallest. Sometimes, from the position of the parts, the tentaculum with its pinnæ presents a spindle-shaped appearance.

Note on two New Species of the Genus Edwardsia.

Edwardsia Allmanni, n. s.—Found on the beach at St Andrews after an October storm. This actinia inhabits a very apparent free tube. The tentacles can be retracted, and the external border of the disc pouted over them. The disc is marked by eight alcyonian divisions or radii, and has always a ragged border of the investing sac. The colour of the disc is pale brown or dark flesh tint.

Tentacles simple, rather blunt, pale and translucent, with a white streak in the centre. The rim of the mouth occasionally protruded as a conical process.

Case composed of a vast number of diatomaceæ, entangled in a basis of tough cells and granules, developing algæ and débris of

various kinds; and it gradually increased in density from the growth of its constituent structures, and probably from the shedding of mucus.

The presence of the case distinguishes it from Peachia and Halcampa; from the former it is also separated by the fact of the tentacles being wholly retractile within the swollen disc. It seems most nearly allied to Edwardsia, though the case was much larger than any previously mentioned, and its tentacles were also blunter and shorter.

Edwardsia Goodsiri, n. s.—Found with the foregoing; sheath less perfect. It constantly protruded a pale bladdery portion with minute suckers posteriorly, and was more lively and sensitive than the former. When fully contracted, it assumed the shape of a Roman jar, and measured less than $\frac{1}{8}$th of an inch in length.

Tentacles fifteen, translucent, longer than the diameter of the oral disc, and not tapering much. At the tip of each, under a low power is seen a slightly opaque whitish ring; then the tentacle is perfectly transparent for a short distance. From the base, a white spear-head reaches more than half-way up, its centre, however, showing the transparent texture.

Oral disc streaked with white and light brown; mouth not observed to project. Column behind the tentacles pale.

When fully extended, it measures about half an inch, the posterior pellucid portion forming nearly the half of this. The anterior part of the latter, however, is tinged of a light fawn colour from the viscera.

3. Miscellaneous Observations on the Blood. By John Davy, M.D., F.R.SS. Lond. & Edin. &c.

These observations are given in six sections.

In the first, "On the Action of Water on the Red Corpuscles of the Blood," the results are stated of trials of different proportions of water on these corpuscles; from which it would appear, that two of water to one of cruor of the blood of the common fowl, sufficed to change the form of the corpuscles, and to render them globular. Other changes are described, which were witnessed when water in great excess was used,—changes referred by the author to endos-

mosis and exosmosis, and rupture of the corpuscles, and the exclusion of their nuclei.

In the second, "On the Changes which take place in the Blood when excluded from air," it is shown that these changes are much the same as when blood is exposed to the air, the difference being chiefly in degree as to time, the accordance, it is inferred, owing to the presence of oxygen in the blood itself, the retained oxygen being sufficient to originate putrefactive decomposition.

In the third, "On the Action of the Air-pump on the Blood," it is stated by the author that the results obtained were more various than he could have expected. Some of them were the following:—Of the several animals of which the blood was tried (the common fowl, the duck, sheep, bullock, pig), least air was procured from that of the common fowl; more from the blood of animals killed after feeding than after fasting; more from venous than arterial blood; none from serum of the blood; this last result confirmatory of the inference that the air—the extricable air—is chiefly derived from the red corpuscles, &c.

In the fourth, "On the Effects of a Low Temperature on the Blood," results are described showing that the freezing of the blood does not preserve it from change of composition, ammonia having been found evolved from it when frozen; and that evolution of the volatile alkali takes place from stable dung when frozen, and from some other manures; but that muscle (meat) in its frozen state does not appear to be liable to the same change.

In the fifth, "On the Action of Ammonia on the Blood," an account is given of the effects of different proportions of aqua ammoniæ on the entire blood, and on its fibrin, its serum, and red corpuscle. The results obtained were such as to confirm the inference that the coagulation of the blood is nowise owing to escape of the volatile alkali, a very large proportion of ammonia not preventing coagulation.

In the sixth, "On the Coagulation of the Blood," some remarks are offered on one of the latest hypotheses brought forward to account for the phenomenon, the hypothesis of Professor Lister tending to show that that hypothesis is not sufficiently founded on fact, and concluding with the expression of belief, that the *vera causa* of the change is still to be discovered.

The following Gentleman was elected an Ordinary Fellow:

John Moir, M.D., F.R.C.P.E.

The following donations were laid on the table:—

Journal of the Asiatic Society of Bengal. No. 4 (with Supplement), 1864. Calcutta, 1864. 8vo.—*From the Society.*

Annales des Mines, ou recueil de Memoires, sur l'Exploitation des Mines et sur les Sciences et les Arts qui s'y rattachent, redigés, par les Ingenieurs des Mines. Tom. V. VI. VII. 1864. Paris 1864. 8vo.—*From the Ecole des Mines.*

Journal of the Royal Dublin Society. Nos. 32 and 33. Dublin, 1865. 8vo.—*From the Society.*

The Journal of Agriculture, and the Transactions of the Highland and Agricultural Society of Scotland. No. 88. Edinburgh, 1865. 8vo. *From the Highland Society.*

Proceedings of the British Meteorological Society. Vol. II., No. 16. London, 1865. 8vo.—*From the Society.*

A General Description of Sir John Soane's Museum. New Edition. London. 12mo.—*From the Trustees.*

Quarterly Return of the Births, Deaths, and Marriages registered in the Divisions, Counties, and Districts of Scotland, for Quarter ending 31st December 1864 (with Supplement.) Edinburgh, 1865. 8vo—*From the Registrar-General.*

Monthly Return of Births, Deaths, and Marriages, registered in the Eight Principal Towns in Scotland, for January 1865, with Supplement to the Monthly Returns for 1864. 8vo.—*From the Registrar-General.*

Proceedings of the Royal Horticultural Society. Vol. V. No. 2. London, 1865. 8vo.—*From the Society.*

Report on the Formation of the Canterbury Plains, with a Geological Sketch Map, and Five Geological Sections. By Julius Haast, Ph.D., &c., Provincial Geologist. Christ Church, 1864. Folio.—*From the Author.*

Report on the Geological Survey of the Province of Canterbury. By Julius Haast, Ph.D., &c. Christ Church, 1864. Folio.—*From the Author.*

Récherches Astronomiques de l'Observatoire d'Utrecht. Par M. Hoek. La Haye, 1864. 4to.—*From the Author.*

Récherches sur la quantité d'Ether, continue dans les Liquides. Par M. Hoek, et A. C. Oudemans. La Haye, 1864. 4to.—*From the Authors.*

Nova Acta Academiæ Cæsareæ Leopoldino-Carolinæ Germanieæ, Naturæ Curiosorum. Dresden, 1864. 4to.—*From the Academy.*

Monday, 20th March 1865.

SIR DAVID BREWSTER, President, in the Chair.

The following Communications were read:—

1. On the Pronunciation of Greek. By Professor Blackie.

I. On the revival of learning at the middle of the fifteenth century, the Hellenists of Europe took the pronunciation of Greek from their teachers, the learned Greek refugees who fled from Constantinople when that city was taken by the Turks in 1453, and who carried with them the Greek language, both as the living people who used it, and as the inheritors of the rich store of philological learning accumulated by an unbroken succession of Alexandrian, Roman, and Byzantine scholars.

II. This Greek pronunciation of Greek remained undisturbed among European scholars till Erasmus, in the year 1528, published an essay on Greek pronunciation, at Basle, to prove that the Byzantine Greeks had in this matter departed in many points from the practice of their ancestors. The effect of this essay was not to reconstruct the lost pronunciation of classical Greek upon any scientific basis, but merely to unsettle the minds of men, and to set every European people upon the task of inventing a pronunciation of Greek according to their own conceit, and after the model generally of their own national peculiarities. The consequence of this unreasoning procedure has been that Babel of confusion which now reigns with regard to the pronunciation of that noble language, of

which the living Greeks with so much reason complain, and which, in my opinion, it is the duty of philologers, as it now is to a large extent in their power, to remove.

III. In this haphazard creation of a modern pronunciation of Greek according to individual conceit all nations fared ill, but the English by far the worst; for they flung the whole basketful of their phonic anomalies into the Greek grammar, and produced a jargon as like Greek as French would be spoken by a Cockney who had never shown himself beyond the sound of the Bow Bells in Cheapside. The Scotch, partly by following the analogy of their own musical Doric dialect—partly from old habits of familiar intercourse with Continental scholars not under English influence—contrived to preserve a pronunciation of Greek as far as possible removed from the barbarous innovations of their English neighbours, and conformable in some most important respects to the acknowledged practice of the Greeks in the classical periods.

IV. Specially it can be proved by a very distinct passage in Dionysius of Halicarnassus—a rhetorician by profession in the age of Augustus Cæsar (*περὶ συνθέσεως ὀνομάτων*, ch. XIV.)—that the whole series of the vowels *α ε ι ο υ* is pronounced by the Scotch, as by all the Continental nations, correctly, with the single exception of *υ*, which in some parts of Scotland is confounded with *oo*, and not according to the perfect analogy supplied by the native words *guid*, *bluid*, as these words are pronounced by the best speakers of the Scottish dialect, corresponding to the sound of *ü* in German, as in *Bühne*, *Brüder*, &c. It is also certain that the pronunciation of the diphthong *ου* practised by the English is contrary alike to the whole traditions of philology and to the most marked characteristic of the Greek language. All scholars recognise *oo* as the only legitimate pronunciation of that most musical of the diphthongs.

V. About the pronunciation of the other diphthongs in the strictly classical—that is, the Athenian—period, great doubt prevails; but there is good evidence to show that *αι* was pronounced like the same diphthong in the English word *vain*, and *ει* like this diphthong in the English word *receive*, at Alexandria in the time of Callimachus, about two hundred years before Christ. Any attempt to reconstruct the Attic orthoepy of the diphthongs on the principle suggested by Erasmus, of showing how they *ought* to be pronounced

by the most obvious and easy interflow of their vocal elements, can, according to the experience of all languages, issue in no reliable result. Pronunciation is a matter of usage, not of argument.

VI. What is called the modern Greek pronunciation, or that used by the Greeks speaking their own language at the present day, is not modern in our sense of that word—it is Byzantine and Alexandrian; and in its most characteristic elements as old as the oldest Greek manuscripts now existing—as old, we may say more correctly, as the general body of the ante-Nicene theology. That it is a corruption from the oldest classical pronunciation is self-evident, from the fact of its giving the slender sound of ι to half a dozen different vowels and diphthongs. But this is only what may be said with equal truth of French, English, and other languages, which have passed through various stages of culture during successive centuries. Their present pronunciation is, in many important points, a corruption of that which was originally the rule.

VII. In these circumstances, the practical question is not without difficulty how far the Byzantine Greek pronunciation should be acknowledged by those nations who, like the Scotch, have the happiness to use a pronunciation of the vowels and diphthongs, on the whole exhibiting a pretty fair approximation to what can be certainly known about the true pronunciation of Greek in the palmy days of Attic eloquence. It is certain, for instance—or at least extremely likely, for the modern Greeks show sturdy fight on this point—that the Scottish pronunciation of η, as a prolonged *e*, like the long English *a* in *mate*, is classical, while the English and Byzantine pronunciation of that vowel as a long *i* is fundamentally false. Nevertheless, I lean to the opinion recently announced by the French Academy, that the Byzantine pronunciation, notwithstanding some obvious defects, should be accepted as a general basis for the pronunciation of the vowels and diphthongs by all European scholars; and that for these four reasons:—(1.) It is not a modern innovation, but a historical fact of nearly two thousand years' duration in its main points, and must be known to the student of early manuscripts, as the only true key to a whole class of blunders made by the early transcribers. (2.) Though a corruption in some points, it is a characteristic corruption, and, in fact, only the development of a marked national tendency—a tendency well

known to Quintilian, as is evident from the contrast drawn by him between Latin and Greek in the words:—*Quamquam iis major est gracilitas, nos tamen sumus fortiores.* (3.) If adopted, it would form a uniform basis of mutual understanding between all persons, whether scholars or native Greeks, who may use the Greek language; and no other uniform basis is at present possible. (4.) It would tend to keep up a friendly feeling between professional scholars and the living Greek people—a feeling by no means a matter of indifference either to the peace of Europe, or to the growth of a scientific philology.

VIII. But though I willingly follow the French Academicians in assuming the Byzantine pronunciation as the only sure historical basis for the pronunciation of Greek among European scholars, I claim the liberty of making one or two deviations from that traditional norm in the special case of its application to ancient poetry. In this region the mere luxury of sound must always be a legislative element; and as, in reading Chaucer, an English scholar of the present day, if he would enjoy the poetical rhythm, necessarily departs in some points from the pronunciation suitable for the recitation of Tennyson or even Shakspeare, so, in reading Homer, if I depart so far from the Byzantine basis as to pronounce οι with the full vocalism heard in our English word *joy*, rather than with the attenuated sound of the modern Greek itacism, I am only using what every intelligent Greek will consider a most legitimate liberty in the circumstances. For though I may have no means of knowing how Homer enunciated his well-known πολύφλοίσβοιο, I am sure that in the early stage of a language used by such a hardy and vigorous people as the Greeks the extreme *gracilitas* of the modern itacism could not have been a dominating characteristic: rather it seems impossible that the pronunciation of any human language should have remained absolutely without change for a period of nearly 3000 years.

IX. But the sound of the vowels and diphthongs, however important, is only one element in the proper pronunciation. Accent and quantity—that is, pitch, emphasis, and duration of syllabic sound—are matters of no less consequence, and form a no less significant feature in the physiognomy, so to speak, of each particular form of human speech. With regard to quantity, I remark simply

that the practice so common among classical teachers, both in England and Scotland, of allowing short syllables to be pronounced long and long short, except in penultimate syllables, is worthy of all reprobation; nor is there the slightest scientific foundation for the practice recently introduced into some English academies of pronouncing the long vowel, as in māter, with a decidedly different quality from the same vowel when short, as in păter. The long vowel is merely a prolongation of the identical sound heard in the short vowel, as in *jŏb*, *Jōb*, and many familiar English examples. With regard to accent, it is quite certain that both the English and Scottish scholars are altogether wrong; and that the living practice of the Greeks in this matter is the only one that harmonises at once with historical tradition, and with the conclusions of philological science. That the classical Greeks pronounced their language with an exact observance of the accent is a point on which the ancient grammarians are quite decided: they all assume that certain determinate accents are as much the law of living Greek utterance generally as certain quantities are the law of rhythmical composition. Neither do they leave us in the slightest doubt as to what the nature of accent really is. The name *acute* ὀξύς given to the ruling accent plainly marks an elevation of the pitch of the voice on a certain syllable, and the words ἐπίτασις and ἄνεσις technically applied to the acute and grave accents, meaning *tension*, *stress*, or *strain*, and *relaxation* or *remission*, plainly point out the element of emphasis, which gives one syllable of a word a marked preponderance to the ear above the rest. The whole doctrine of enclitics also marks emphasis or stress as an essential element of the Greek accent; and the accented verses of the Byzantine popular poetry and the pronunciation of the modern Greeks all drive us to the same conclusion, which only obstinate prejudice, ignorant conceit, or stolid stupidity can resist. This conclusion is that when Olympian Pericles thundered against Spartan insolence, and Demosthenes against Macedonian aggression, they emphasised the thunderbolts of their speech in the same manner that Greek words are now emphasised by an orator in the modern Greek Parliament, or a muleteer on the ridge of the modern Greek Parnassus.

X. The practice by which the British school of Greek scholars has hitherto been distinguished, of pronouncing Greek by the laws

of Latin accentuation, transmitted to us through the Roman Catholic Church, while at the same time the real Greek accents are carefully marked on every printed page, and taught minutely as a matter of learned indoctrination, is one of the most curious instances of combined carelessness and perversity in the whole history of learning. Had the Greek accents not been marked so curiously on every Greek word in every page of printed Greek for the last four centuries, some excuse might have been found for a practice, for which the *vis inertiæ* of human nature and the Latinised habitude of academic ears so powerfully plead; but as the matter now stands, the persistence in a perverse practice, refuted by every fact in historical tradition, and every argument in philological science, stands as a staring absurdity alone in the annals of scholastic life. The aversion which the English scholars generally have to acknowledging the truth in this matter appears to me to have its origin partly in a gross habit of ear, which renders them unable to appreciate certain musical and elocutional distinctions which underlie the subject, partly in a sort of unreasoning conservatism, which is the backbone of their whole scholastic and academic system, partly also, and principally, perhaps, from a vague imagination they entertain that the spoken accent of Greek prose has something to do with the rhythmical recitation of Greek verse. Now, it is quite certain that, however distinct the accented syllable was in Greek oratory, in the composition of Greek verse the duration of the vowel sounds was the only element necessarily taken into account, while the spoken accent was either silent altogether or heard with a marked subordination to the accent of the rhythm. And, as a matter of educational practice, nothing is more easy for a boy who has an ear—and he who has none need never read verse—to pass from the accented pronunciation of prose to the quantitative mensuration of poetry without confusion. Even the daily practice of our schools teaches that a boy cannot read a single distich of Ovid rhythmically without putting a stress on the last syllable of the final dissyllable, which is quite contrary to the natural accent of the same word when pronounced in prose.

XI. In conclusion, I have to observe that the pronunciation of all Greek words indiscriminately according to the monotonous Latin accentuation, is merely a part of an entirely false method of

teaching prevalent in the great English schools, according to which dead rules are substituted for living functions, and doctrines about sounds for the sounds themselves. Whosoever as a teacher of languages has seized on the great principle that the ear is the special organ used by nature in acquiring a knowledge of articulate sounds, will never commit the mistake of pronouncing ἔλεος, the divine attribute of mercy, with the same intonation that marks ἐλεός, a *wooden block for washing mince-collops*. The Greek language contains whole columns of such words, which the man who pronounces Greek according to Latin accents must pervert and turn into nonsense. To teach any language with false accents and false quantities, and yet to inculcate rules about true accents and true quantities, is to declare the schoolmaster wiser than the Creator, and to insist on doing by a forced and painful process of memory what nature is willing to do for us by the pleasant habituation of the ear.

2. Note on Action. By Professor Tait.

The quantity represented by $\int vds$, or its equivalent $\int v^2dt$, in any case of the motion of a particle, is known to possess important dynamical relations. The accidental discovery of a singularly simple geometrical representation of this quantity in the case of planetary motion led me to inquire whether the method involved might not be easily generalized. This note contains a sketch of some of the results of a hurried investigation of the point.

Graphical representations of the action in some common cases of motion readily suggest themselves.

Thus, in the case of the parabolic trajectory of an unresisted projectile, the action through any arc of the path is proportional to the area included between that arc, the directrix, and two ordinates parallel to the axis; while the time is, of course, represented by the intercept on the directrix.

Again, in the case of the ordinary brachistochrone (the cycloid with its vertex downwards), the action and the time, corresponding to any arc from the cusp, are respectively proportional to the area and the arc of the corresponding segment of the generating circle.

Numerous other simple cases might be given, but these are suffi-

cient to show that such representations depend mainly upon the particular nature of the path, and therefore cannot be included in any general formula. But the example which follows appeared to point out some such general method; applicable at least to central orbits.

In an elliptic orbit described about the focus, the time is proportional to the sectorial area described about one focus, and the action to that about the other.—The proof of this theorem is obvious, if we remember that the product of the perpendiculars, from the foci, upon the tangent to an ellipse, is constant.

This appeared to me to indicate, as a mode of representing the action in a central orbit, the seeking for a curve allied to the orbit, and in its plane; such that, if two tangents be drawn to it, the area intercepted between them, the curve, and the orbit, shall be proportional to the action. In the case of the elliptic orbit, above referred to, this curve would evidently become a point, viz., the second focus. The following investigation, however, does not give a very encouraging result :—

Taking the centre of force as origin, let x, y, be the co-ordinates of a point in the orbit, ξ, η, those of the corresponding point in the allied curve. The equation of the tangent at x, y, is

$$(x-x')\frac{dy}{ds}-(y-y')\frac{dx}{ds}=0;$$

and, consequently, the lengths of the perpendiculars drawn to it from the origin, and from the point ξ, η, are

$$p=x\frac{dy}{ds}-y\frac{dx}{ds},$$

and

$$p'=(x-\xi)\frac{dy}{ds}-(y-\eta)\frac{dx}{ds},$$

respectively. That the elementary triangle, whose vertex is ξ, η, and whose base is δs, may be proportional to the element of the action, we must evidently (as we see by referring to the case of the ellipse above) have

$$pp'=\text{constant}.$$

Hence our first condition is

$$\left(x\frac{dy}{ds}-y\frac{dx}{ds}\right)\left((x-\xi)\frac{dy}{ds}-(y-\eta)\frac{dx}{ds}\right)=a^2,$$

or, in a somewhat more convenient form,

$$\eta \frac{dx}{ds} - \xi \frac{dy}{ds} = -p + \frac{a^2}{p} \quad \ldots \ldots \quad (1).$$

Also, by the nature of the construction we are attempting, it is obvious that the line joining the points x, y, and ξ, η, must be a tangent to the locus of ξ, η. This gives us at once the second condition

$$\frac{d\eta}{d\xi} = \frac{\eta - y}{\xi - x} \quad \ldots \ldots \ldots \quad (2.)$$

Since, by the equation of the central orbit, which is supposed to be known, we have x and y in terms of s, we may take s as independent variable, and we have the equations (1) and (2) necessary and sufficient for the determination of ξ and η in terms of s.

Eliminating η by differentiation and substitution, we find for ξ the equation

$$\frac{a^2}{p} \frac{dx}{ds} \frac{d\xi}{ds} = (\xi - x) \left\{ (\xi - x) \left(\frac{dx}{ds} \frac{d^2y}{ds^2} - \frac{dy}{ds} \frac{d^2x}{ds^2} \right) \right.$$
$$\left. - \frac{a^2}{p^2} \left[x \left(\frac{dx}{ds} \frac{d^2y}{ds^2} + \frac{dy}{ds} \frac{d^2x}{ds^2} \right) - 2y \frac{dx}{ds} \frac{d^2x}{ds^2} \right] \right\}$$

with, of course, a similar equation for η.

If we take x as the independent variable, and put

$$Y = \frac{a^2 \left(1 + \left(\frac{dy}{dx}\right)^2\right)}{x \frac{dy}{dx} - y}, \text{ a } \textit{given} \text{ function of } x,$$

it is easy to reduce this equation to

$$\frac{d}{dx}\left(\frac{Y}{x - \xi}\right) + \frac{Y}{(x - \xi)^2} = \frac{d^2y}{dx^2},$$

which seems to be the simplest form to which it can be brought, unless special relations between x and y are introduced, and without such it seems to be quite intractable.

The remainder of the paper refers to a subject which, though allied to action, is so distinct from the investigation above that I give the following abstract of it under a distinct title.

3. On the Application of Hamilton's Characteristic Function to Special Cases of Constraint. By Professor Tait.

Hamilton's beautiful theory of Varying Action reduces to the discovery of a single function any problem connected with motion under the action of a conservative system of forces, and with constraint by any system of smooth fixed surfaces.

It does not appear to have been applied to cases (such as the brachistochrone) in which the requisite constraint is the thing to be determined.

Taking $\tau = \int \frac{ds}{v}$, the *time* in the brachistochrone, it is shown that we have, τ being regarded as a function of x, y, z,

$$\left(\frac{d\tau}{dx}\right)^2 + \left(\frac{d\tau}{dy}\right)^2 + \left(\frac{d\tau}{dz}\right)^2 = \frac{1}{v^2} = \frac{1}{2(H-V)},$$

where H is the whole energy, and V the potential of the given system of forces. If a complete integral of this equation can be found, we have

$$\frac{dx}{dt} = 2(H-V)\frac{d\tau}{dx}, \text{ \&c.}$$

Also, if α, β, be constants in the expression for τ,

$$\frac{d\tau}{d\alpha} = \mathfrak{A}, \frac{d\tau}{d\beta} = \mathfrak{B},$$

where $\mathfrak{A}$ and $\mathfrak{B}$ are two new constants, are the equations of the brachistochrone.

Various properties of brachistochrones, and the corresponding free paths, are deduced from these equations; the connection between this process and that of Hamilton is illustrated by the solution of problems in optics, based on the corpuscular and on the undulatory theories; and the paper concludes with an application of the principle to cases in which the characteristic function is of such forms as

$$\int f(v)\, ds \qquad \text{or} \qquad \int \mathrm{F}(x,y,z)\, f(v)\, ds$$

where f and F are given functions.

4. On Transversals. By the Rev. Hugh Martin, Free Greyfriars.

This paper contains upwards of seventy theorems, in great part new, with reference to the intersection of systems of lines. The demonstrations are based upon determinants.

5. On the Motion of a Heavy Body along the circumference of a Circle. By Edward Sang.

This paper contains a demonstration of the theorem given in the fourth volume of the proceedings at p. 419.

The theorem in question was arrived at by the comparison of the well-known formula for the time of descent in a circular arc, with another formula given in the "Edinburgh Philosophical Magazine" for November 1828, by a writer under the signature T. W. L. Each of these series is reached by a long train of transformations, developments, and integrations, which require great familiarity with the most advanced branches of the higher calculus. Yet the theorem which results from their comparison has an aspect of extreme simplicity, and seems as if it could be reached by an easier road. A search for this easier road has led to the discovery of a few simple propositions, which contain the whole theory of motion in a circle, and which only require for their examination a knowledge of the fundamental law of dynamics, and an acquaintance with trigonometry.

There are two distinct cases of motion in a circle, viz., one in which the heavy body describes with a varying velocity the whole circumference; the other in which the motion is oscillatory, as in the example of a pendulum. The first step of the investigation is to establish a relation between a continuous and an oscillatory motion, such that their periodic times bear a certain ratio to each other. To these two motions the name *conjugate* is given. By means of this relation the problem, "to compute the time of revolution" in the case of continuous motion, can be converted into another problem, "to find the descent in a circular arc," and contrariwise.

The second step is to deduce from this pair of conjugate motions a second pair of motions also conjugate to each other, and having their periodic times in simple ratios to those of the preceding pair.

The third step is to form a progression of pairs of conjugate motions deduced successively one from another. In this progression, carried in the direction inverse to that just mentioned, the motions approach with extreme rapidity, on the one hand to a uniform circular motion, on the other hand to the oscillation in an exceedingly minute arc.

As a practical result of the whole, it is shown that, for all cases of clock motions, and for experiments to determine the length of the seconds pendulum, the time of oscillation may be held to be proportional to the square of the secant of the eighth part of the whole arc described; the number of oscillations per day to be proportional to the square of the cosine of the same eighth part; and the daily retardation to the square of the sine.

6. On the Action of Hydriodic Acid on Mandelic Acid. By Alex. Crum Brown, M.D., D.Sc.

The relation of mandelic acid to benzoic aldehyd is so precisely the same as that of lactic acid to acetic aldehyd, that whatever constitution we assume for the latter acid, a similar one must be ascribed to the former.

The researches of Kolbe and Lautemann, and of Wislicenus, prove that lactic acid is oxypropionic acid. Mandelic acid must therefore be oxytoluic acid, and, indeed, it has been so formulated by Kolbe in his work on Organic Chemistry.

While agreeing with Kolbe and Wislicenus, I prefer, for some purposes, to employ formulæ slightly different from those of either of these chemists.

Thus, using Ξ as a contraction for $\left.\begin{matrix}\cdot\\ HO\end{matrix}\right\} CO$, the relation of aldehyd, chloride of ethyliden, ethylidenic chlorhydrine, and common lactic acid, may be expressed by the formulæ

$$\left.\begin{matrix}CH_3\\ H\end{matrix}\right\} CO, \quad \left.\begin{matrix}CH_3\\ H\end{matrix}\right\} CCl_2, \quad \left.\begin{matrix}CH_3\\ H\end{matrix}\right\} C \left\{\begin{matrix}Cl\\ (HO),\end{matrix}\right. \quad \text{and}$$

$$\left.\begin{matrix}CH_3\\ H\end{matrix}\right\} C \left\{\begin{matrix}\Xi\\ (HO).\end{matrix}\right.$$

It is thus shown *which* of the atoms of hydrogen in propionic acid $\left.\begin{matrix} CH_3 \\ H \end{matrix}\right\} C \left\{\begin{matrix} \Xi \\ H \end{matrix}\right.$ is replaced by the water residue HO to form common lactic acid, and the latter is distinguished from sarcolactic acid

$$\left.\begin{matrix} CH_2(HO) \\ H \end{matrix}\right\} C \left\{\begin{matrix} \Xi \\ H. \end{matrix}\right.$$

Replacing CH_3 in these formulæ by C_6H_5 we get the formulæ of the corresponding substances in the aromatic series.

The complete analogy between lactic and mandelic acids as to the mode of their formation naturally suggests the idea that their decompositions should also be analogous; and yet, considering that no oxyacid of the aromatic series had as yet been directly reduced to the corresponding normal acid, it seemed to me to be of interest to examine the reaction of hydriodic acid on mandelic acid, in order to see whether it follows the analogy of salicylic or of lactic acid, and if the latter, to compare the toluic acid thus produced with the two isomeric acids at present known.

For this purpose, mandelic acid was boiled with concentrated aqueous hydriodic acid and phosphorus in a flask fitted to an ascending Liebig's condenser, so that the vapours of hydriodic acid condensed, and ran back into the flask. Notwithstanding the presence of excess of phosphorus, the liquid immediately became opaque from the separation of a large quantity of free iodine, and the drops of condensed hydriodic acid became milky. After boiling for about half an hour, the reaction was complete, and the iodine was removed by the phosphorus. The clear liquid, while still hot, was decanted from the excess of phosphorus, and on cooling solidified to a crystalline magma. The crystals, when drained and recrystallised once or twice from boiling water, presented the following properties:—

Large extremely thin iridescent plates, closely resembling those of benzoic acid, but without the serrated character of the latter; readily soluble in hot, sparingly in cold water; readily soluble in alcohol, ether, and solutions of the hydrates and carbonates of the alkalies. When treated with boiling water, they at first fuse to a colourless oil denser than water, and subsequently dissolve, and when a hot saturated solution is cooled, the substance is at first deposited in the liquid state.

Both the solution and the crystals have a strong and persistent smell of honey.

When heated, the crystals fuse, and at a higher temperature boil, readily volatilising far below the boiling point.

The fusing point was found to be 76° C., and the boiling point (corrected) 264° C.

Combustion with oxide of copper and oxygen gave the following results:—

I. 0·2422 grm. gave 0·1344 water.

II. 0·2212 grm. gave 0·1297 water and 0·5803 carbonic acid.

Indicating the formula $C_8H_8O_2$.

	Calculated.		Observed. I.	Observed. II.
C_8	96	70·6	...	71·5
H_8	8	5·9	6·2	6·5
O_2	32	23·5	...	...
	136	100·0		

Hydriodic acid, therefore, acts in the same way on mandelic acid as on lactic acid. The reaction probably takes place in two stages, and may be expressed thus:—

$$\left.\begin{matrix}C_6H_5\\H\end{matrix}\right\}C\left\{\begin{matrix}\Xi\\HO\end{matrix}\right.+HI=\left.\begin{matrix}C_6H_5\\H\end{matrix}\right\}C\left\{\begin{matrix}\Xi\\I\end{matrix}\right.+H_2O$$

$$\left.\begin{matrix}C_6H_5\\H\end{matrix}\right\}C\left\{\begin{matrix}\Xi\\I\end{matrix}\right.+HI=\left.\begin{matrix}C_6H_5\\H\end{matrix}\right\}C\left\{\begin{matrix}\Xi\\H\end{matrix}\right.+I_2.$$

A lime salt prepared by boiling the acid with powdered Iceland spar crystallised in radiated needles, readily soluble in water. Analysis of the salt dried in *vacuo* over sulphuric acid gave the following results:—

I. 0·0977 grm. lost 0·0101 at 130° C.

II. 0·2459 grm. gave 0·0386 quicklime.

III. 0·2674 grm. gave 0·0419 quicklime.

These results agree with the formula $C_{16}H_{14}CaO_4 + 2H_2O$.

	Calculated.		Observed. I.
$C_{16}H_{14}CaO_4$	310	89·6	89·7
$2H_2O$	36	10·4	10·3
	346	100·0	100·0

	Calculated.		Observed. II.	III.
C_{16}	192	55·5	...	...
H_{18}	18	5·2	...	...
Ca	40	11·3	10·9	11·18
O_6	96	28·0	...	...
	346	100·0		

The silver salt forms small, indistinct, white scales, soluble in boiling water. The copper salt is a bright green amorphous precipitate. The ferric salt, a pale brown precipitate, exactly like the ferric benzoate.

The acid resists the action of dilute sulphuric acid and bichromate of potash, even when boiled; when heated with strong sulphuric acid and bichromate it is oxidised, and gives off the smell of oil of bitter almonds. Fuming nitric acid readily dissolves the acid when heated, the solution becoming at first red, then colourless, and on cooling, a nitro-acid crystallises out. This nitro-acid forms colourless crystals, which dissolve in solutions of the alkalies with a yellow colour. I am at present engaged in its examination, and hope to obtain from it the corresponding amido- and oxy-acids.

A comparison of the properties of the toluic acid thus prepared from mandelic acid with those of Möller and Strecker's alpha-toluic acid from vulpic acid,* leaves no doubt of their identity. The fusing point of alpha-toluic acid is 76·5, that of the acid from mandelic acid is 76°·0; the former boils at 265° 5, the latter at 264°. All the characters of alpha-toluic acid, with the exception of the smell, are so exactly the same as those of the acid from mandelic acid, that there is not a word in Möller and Strecker's description of the former which does not perfectly apply to the latter.

The reduction of mandelic acid to alpha-toluic acid appears to prove, 1*st*, that, notwithstanding its lower fusing point, the latter acid is the true homologue of benzoic acid.†

2*d*, That the reduction of the oxy-acids to the normal acids by the action of hydriodic acid is not peculiar to the fatty series, and

* Ann. Ch. Pharm. cxiii. 56.

† The irregularity in the fusing point is not surprising, considering that benzoic acid is probably the first term in the series, and that a similar irregularity is observed in the case of the lower terms of the series of fatty acids.

probably depends on the "chemical position" of the alcoholic water residue in the molecule.

Recollecting that benzoic aldehyd has been prepared from benzoic acid by Piria and by Chiozza, we see that by three processes, 1*st*, the subtraction of oxygen; 2*d*, the addition of the elements of formic acid; and, 3*d*, the subtraction of oxygen, we have advanced one step in the homologous series of the aromatic acids; and, as far as we can see, there is nothing to prevent the repetition of this step, and the gradual ascent of the series.

With a view to ascertain whether this is possible, I have treated cuminol with hydrocyanic and hydrochloric acids, and the results obtained are sufficient to encourage me to continue the investigation.

7. On the Nature of Antozone. By Alfred R. Catton, B.A., F.R.S.E., Fellow of St John's College, Cambridge, and Assistant to the Professor of Natural Philosophy in the University of Edinburgh.

Many of the properties of ozone are very similar to those of peroxide of hydrogen. Thus ozone, like peroxide of hydrogen, is in many cases a powerful oxidising agent. In other cases, however, it acts as a deoxidiser. Thus ozone deoxidises peroxide of hydrogen and peroxide of barium with the production of water and oxide of barium. Peroxide of hydrogen also deoxidises oxide of silver, the peroxides of manganese and lead, permanganic and chromic acids, &c. Again, ozone is decomposed catalytically by dry silver leaf and by several oxides, such as the peroxides of manganese and lead, &c. Peroxide of hydrogen is also decomposed catalytically by several metals—gold, silver, platinum, and metallic oxides. Ozone liberates iodine from a solution of iodide of potassium. Peroxide of hydrogen does the same by the mere addition of a few drops of protosulphate of iron, the latter undergoing no change during the reaction.

We see then that the general properties of ozone are very similar to those of peroxide of hydrogen. If, however, we examine the properties of these compounds in detail, we find that their particular properties are complementary to each other. In other words, for the particular compounds for which ozone acts as an oxidising agent, peroxide of hydrogen does not act as an oxidising, but in

general as a reducing agent. Thus mercury and silver are converted by ozone into oxides. These oxides are reduced to the metallic state by peroxide of hydrogen.

A piece of paper moistened with sulphate of manganese is turned brown by ozone, owing to the formation of peroxide of manganese. The peroxide of manganese thus formed is reduced by peroxide of hydrogen to the state of protoxide. Similarly, by the action of ozone on subacetate of lead paper, peroxide of lead is formed, which is again reduced to protoxide of lead by peroxide of hydrogen.

Peroxide of barium is produced by the action of peroxide of hydrogen on hydrated protoxide of barium. Peroxide of barium is on the contrary reduced by ozone to oxide of barium; the ferrocyanide of potassium is converted by ozone into ferricyanide, which latter is again reduced by peroxide of hydrogen.

This opposition in the characters of ozone and peroxide of hydrogen, indicated by their action on other compounds, is maintained in their action on each other. Though peroxide of hydrogen and ozone are both powerful oxidising agents, by their action on each other two neutral substances are produced, water and ordinary oxygen. These characters naturally suggest the idea that ozone and peroxide of hydrogen are related to each other, much in the same way as acids and bases, which, though both possessed of decided characters, mutually neutralise each other. In other words, that the characters of ozone and peroxide of hydrogen bear to each other that relation which is indicated by the words electro-negative and electro-positive; a conclusion remarkably confirmed by the production of ozone during the electrolysis of an acid liquid at the positive pole, and of peroxide of hydrogen at the negative pole, as shown by Meidinger, thus showing that ozone is to be regarded as an electro-negative compound, and peroxide of hydrogen as an electro-positive compound. And as ozone and peroxide of hydrogen neutralise each other, so to speak, we are led to suppose that they are each formed by the combination of the same number of molecules. We are thus led to assign to ozone the formula OOO (O = 16) as suggested by the equation

$$\overbrace{H_2OO}^{+} + \overbrace{OOO}^{-} = H_2O + 2\,(OO)$$

The signs placed over the bracket merely denoting that H_2OO as a whole is to be considered as an electro-positive compound, and OOO as electro-negative.

This view of the constitution of ozone is due to Professor Odling (Manual of Chemistry, 1861), and the most important argument in its favour is the non-diminution in volume of ozonised oxygen when the ozone is decomposed by iodide of potassium or mercury (*loc. cit.* p. 94).

The existence of antozone has been fully established by the experiments of Schönbein and Meissner.

The latter has shown that when electric discharges are passed through dry oxygen, another substance, antozone, is produced besides ozone. If the latter be destroyed by passing the electrised oxygen through a strong solution of iodide of potassium, antozone remains mixed with ordinary oxygen.

The properties of antozone can thus be observed. One of the most characteristic of these is the formation of a thick white mist when passed into water. This same white mist is also formed when the gas produced by the action of concentrated sulphuric acid on peroxide of barium is passed into water. In the latter case, therefore, antozone is produced, and not ozone (as stated by Houzeau).

Now, on examining the characters of antozone as far as they have hitherto been observed, we find that, instead of being complementary to those of peroxide of hydrogen, as in the case of ozone, they correspond with them very closely. In other words, where peroxide of hydrogen acts as a reducing agent, antozone does so also.

Thus a paper moistened with sulphate of manganese, and coloured brown by ozone, is again decolorised by antozone, owing to the reduction of the peroxide of manganese at first formed to the state of protoxide. Peroxide of manganese is also reduced by peroxide of hydrogen.

Similarly, a paper moistened with subacetate of lead, and discoloured by ozone, is again whitened by antozone, owing to the reduction by the latter of the peroxide of lead first formed to protoxide of lead. Peroxide of lead is also reduced by peroxide of hydrogen.

Similarly, dilute acidulated solutions of bichromate and perman-

ganate of potassium are reduced by antozone. Peroxide of hydrogen also reduces chromic and permanganic acids and their salts.

We are thus led to regard antozone as a compound analogous in constitution to peroxide of hydrogen; in other words, to regard antozone as peroxide of hydrogen, in which the hydrogen is replaced by oxygen, or representing, as before, peroxide of hydrogen by $+(H_2OO)$, antozone is $+(OOO)$, and ozone $-(OOO)$. The $+$ and $-$ signs being merely used to denote the idea that one compound acts as electro-positive and the other as electro-negative.

If we adopt the hypothesis that free oxygen is formed by the combinations of two atoms of oxygen $(O=16)$, one of which acts as an electro-positive and the other as an electro-negative atom, free oxygen is $\overset{+}{O}\,\overset{-}{O}$.

Hence, since free oxygen is produced when ozone is decomposed by mercury, ozone must be either $\overset{-}{O}\,\overset{+}{O}\,\overset{-}{O}$ or $\overset{-}{O}\,\overset{-}{O}\,\overset{+}{O}$, in accordance with the equations

$$\overset{+}{Hg_2} + \overset{-}{O}\,\overset{+}{O}\,\overset{-}{O} = \overset{+}{Hg_2}\,\overset{-}{O} + \overset{+}{O}\,\overset{-}{O}, \text{ or}$$

$$\overset{+}{Hg_2} + \overset{-}{O}\,\overset{-}{O}\,\overset{+}{O} = \overset{+}{Hg_2}\,\overset{-}{O} + \overset{-}{O}\,\overset{+}{O}.$$

The latter formula is inadmissible, because, as we have shown, ozone acts as an electro-negative compound, which therefore requires that the two outside atoms should both be electro-negative. For $\overset{-}{O}\,\overset{-}{O}\,\overset{+}{O}$ would neither be decidedly electro-negative nor decidedly electro-positive. Hence ozone is $\overset{-}{O}\,\overset{+}{O}\,\overset{-}{O}$, which is the view of Professor Odling.

Sir Benjamin Brodie has shown (Phil. Trans. 1850) that the reducing properties of peroxide of hydrogen require us to assign to it the formula $\overset{+}{H_2}\,\overset{-}{O}\,\overset{+}{O}$. Hence antozone is $\overset{+}{O}\,\overset{-}{O}\,\overset{+}{O}$, a formula which indicates that antozone acts as an electro-positive compound. The production of ozone and antozone by the passage of electric sparks, or the silent discharge through dry oxygen, is thus represented by the following equation :—

$$\underbrace{\overset{-}{O}\,\overset{+}{O} + \overset{-}{O}\,\overset{+}{O} + \overset{-}{O}\,\overset{+}{O}}_{\text{Ordinary Oxygen.}} = \underbrace{\overset{-}{O}\,\overset{+}{O}\,\overset{-}{O}}_{\text{Ozone.}} + \underbrace{\overset{+}{O}\,\overset{-}{O}\,\overset{+}{O}}_{\text{Antozone.}}.$$

These formulæ indicate hypothetically why antozone combines

with water to form peroxide of hydrogen, but not ozone. For, in accordance with the electrical theory of chemical action, the following reaction is perfectly possible :—

$$\begin{array}{ccccccc} \text{Water.} & & \text{Antozone.} & & \text{Peroxide of Hydrogen.} & & \text{Oxygen.} \\ \overset{+}{H}_2\overset{-}{O} & + & \overset{+}{O}\overset{-}{O}\overset{+}{O} & = & \overset{+}{H}_2\overset{-}{O}\overset{+}{O} & + & \overset{-}{O}\overset{+}{O}. \end{array}$$

Peroxide of hydrogen cannot, however, be formed by the combination of $\overset{+}{H}_2\overset{-}{O}$ and $\overset{-}{O}\overset{+}{O}\overset{-}{O}$.

Again, it gives an explanation of the formation of antozone by the action of oil of vitriol on peroxide of barium. For we may suppose the peroxide of barium to decompose in the following manner :—

$$\overset{+}{Ba}_2\overset{-}{O}\overset{+}{O} = \overset{+}{Ba}_2\overset{-}{O} + \overset{+}{O}.$$

The oxide of barium being formed as sulphate of barium. $\overset{+}{O}$ then combines with some of the ordinary oxygen also given off at the same time with the formation of antozone :—

$$\overset{+}{O}\overset{-}{O} + \overset{+}{O} = \overset{+}{O}\overset{-}{O}\overset{+}{O}.$$

It must not be supposed that by the algebraic signs here used it is intended to denote that the atoms of oxygen preserve any absolute electric state. Although in a compound oxygen may act as $\overset{+}{O}$, we must guard against imagining that in any chemical action $\overset{+}{O}$ cannot be transformed even with the greatest facility into $\overset{-}{O}$. The fact of the production of free oxygen in the action just referred to shows that such is the case. Sulphuric acid is a highly electro-negative compound, and we can easily understand how the positive electricity of $\overset{+}{O}$ is neutralised by the sulphuric acid, and how $\overset{+}{O}$ is even changed into $\overset{-}{O}$.

Again, by the action of heat on peroxide of hydrogen, it is decomposed into water and ordinary oxygen. We must here suppose that the peroxide decomposes thus—

$$\overset{+}{H}_2\overset{-}{O}\overset{+}{O} = \overset{+}{H}_2\overset{-}{O} + \overset{+}{O},$$

and that half of the $\overset{+}{O}$ is changed by heat into $\overset{-}{O}$ in order to form

inactive oxygen $\overset{+}{O}\overset{-}{O}$. This supposition is also necessary in order to explain the conversion of ozone and antozone by heat into ordinary oxygen.

It is probable that the protosulphate of iron in the method of testing for peroxide of hydrogen exerts a similar action. Having a strong affinity for oxygen, it decomposes the peroxide into $\overset{+}{H}_2\overset{-}{O}$ and $\overset{+}{O}$, and at the same time converts the latter into $\overset{-}{O}$, which then decomposes the iodide of potassium thus:—

$$\overset{+}{K}_2\overset{-}{I}_2 + \overset{-}{O} = \overset{+}{K}_2\overset{-}{O} + I_2.$$

This last reaction being similar to that of the decomposition of iodide of potassium by ozone:—

$$\overset{+}{K}_2\overset{-}{I}_2 + \overset{-}{O}\overset{+}{O}\overset{-}{O} = \overset{+}{K}_2\overset{-}{O} + \overset{+}{O}\overset{-}{O} + I_2.$$

The production of antozone by the action of sulphuric acid on peroxide of barium is perfectly analogous to the formation of peroxide of hydrogen by the action of carbonic dioxide on peroxide of barium, thus—

$$\overset{+}{Ba}_2\overset{-}{O}\overset{+}{O} + CO_2 = \overset{\text{Carbonate of Barium.}}{Ba_2OCO_2} + \overset{+}{O}$$

$$\overset{+}{H}_2\overset{-}{O} + \overset{+}{O} = \overset{\text{Peroxide of Hydrogen.}}{\overset{+}{H}_2\overset{-}{O}\overset{+}{O}}.$$

It might be supposed, from these views of the constitution of ozone and antozone, that when in contact they ought to combine with each other to produce ordinary oxygen. There is, however, no more reason that this should be the case than that an electro-positive element like hydrogen should combine with oxygen, which is electro-negative, when mixed with each other. As in the case of hydrogen and oxygen, however, it is possible that ozone and antozone may combine to form ordinary oxygen by the passage of the electric spark. The increase in volume of electrised oxygen by the passage of the spark from a Rühmkorff's coil, may possibly be partially due to this cause, although no doubt owing in great measure to the decomposition of some of the ozone and antozone by heat.

On the contrary, antozone appears, from the experiments of Meissner, to be more stable in the presence of ozone than when mixed with ordinary oxygen.

The following fact may possibly be considered analogous. An aqueous solution of peroxide of hydrogen (an electro-positive compound) is rendered more stable by the addition of an acid, an electro-negative compound, but less stable by the addition of alkalies.

Also, since oxygen is essentially an electro-negative element, we can easily understand why antozone, which we may look upon as containing electro-positive oxygen, gradually decomposes, and is changed into ordinary oxygen, as observed by Meissner. And we can, on the contrary, understand why ozone is a comparatively stable compound.

Schönbein has shown that peroxide of hydrogen is produced in many cases of slow oxidation occurring in the presence of moisture. This is commonly attributed to the formation of antozone, which subsequently combines with water to form peroxide of hydrogen. In the author's view, however, the peroxide of hydrogen is the immediate product of the reaction.

In the oxidation of zinc, for instance,

$$\overset{+}{Zn_2} + \overset{-}{O}\overset{+}{O} + \overset{-}{O}\overset{+}{H_2} = \overset{+}{Zn_2}\overset{-}{O} + \overset{+}{O}\overset{-}{O}\overset{+}{H_2}.$$

Supposing that this view of the constitution of antozone is confirmed by further investigation, it will afford a strong support to the theory that the elements in the free state are formed by the combination of two atoms in opposite electrical states, as well as of the electrical theory of chemical affinity.

Some persons find great difficulty in the supposition that oxygen can combine with itself to form compounds differing entirely in properties from ordinary oxygen. There is, however, in reality no greater difficulty in this supposition than in other admitted cases where a compound combines with itself to form other compounds. Methylene, for instance, when liberated from iodide of methylene by the action of copper and water, combines with itself to form ethylene and tritylene, as shown by M. Boutlerow. Tritylene, in fact, bears to ethylene a somewhat similar relation to that which ozone and antozone bear to oxygen. Again, oxygen, in the language of modern chemistry, is a polyatomic element; and it is a well-

known fact that polyatomic compounds have a great tendency to combine with themselves to produce others of greater complexity.

There is, therefore, *à priori*, nothing improbable in the supposition that oxygen may, under proper conditions, combine with itself; but, on the contrary, the analogies of science are in favour of such a supposition.

It may be well here to repeat, that the author's view of the constitution of antozone freed from all hypothesis as to the electric states of molecules is, that antozone is peroxide of hydrogen, in which the hydrogen is replaced by oxygen.

The following Donations to the Library were announced:—

Monthly Return of the Births, Deaths, and Marriages registered in the Eight Principal Towns of Scotland. February 1865. 8vo.—*From the Registrar-General.*

The Canadian Journal of Industry, Science, and Art. January 1865. Toronto. 8vo.—*From the Editors.*

Die Fortschritte der Physik im Jahre 1862 Dargestillt von der physikalischen Gesellschaft zu Berlin. XVIII. Jahrgang. I. and II. Abtheilung. Berlin, 1864. 8vo.—*From the Society.*

Monthly Notices of the Royal Astronomical Society, London. Vol. XXV. No. 4. 8vo.—*From the Society.*

Proceedings of the Royal Society of London. Vol. XIV. No. 72. 8vo.—*From the Society.*

On the Laurentian Rocks of Britain, Bavaria, and Bohemia. By Sir Roderick I. Murchison, K.C.B., F.R.S. 8vo.—*From the Author.*

On the Origin of the Alpine Lakes and Valleys : A Letter addressed to Sir R. I. Murchison. By M. Alphonse Favre. 8vo.—*From Sir R. I. Murchison.*

Proceedings of the Royal Horticultural Society, London. Vol. V. No. 3. 8vo.—*From the Society.*

On the Utilisation of Sewage, with a Description of the Plan of Messrs Napier and Hope for the Utilisation of the Sewage of London. By George Robertson, C.E., F.R.S.E., &c. 8vo.—*From the Author.*

Annuaire de l'Académie Royale des Sciences, des Lettres et des Beaux-Arts de Belgique, 1865. Brussels. 8vo.—*From the Academy.*

Bulletin de l'Académie Royale des Sciences, des Lettres et des Beaux-Arts de Belgique. No. 1, 1865. Brussels. 8vo.—*From the Academy.*

Nyt Magazin for Naturvidenskaberne—udgives af den Physiographiske Forening i Christiania. Hefte 1, 2, 3. Christiania, 1864. 8vo.—*From the University of Christiania.*

Meteorologische Beobachtungen—Aufgezeichnet auf Christiania's Observatorium. III. and IV. Leiferung, 1848—1855. Christiania, 1864. 4to.—*From the same.*

Om de Gologiske Forbold paa Kyststrækningen af Norde Bergenhus Amt, af M. Irgens og Th. Hiortdahl. Christiania, 1864. 4to. —*From the Authors.*

Om Sneebræen Folgefon, af S. A. Sexe. Christiania, 1864. 4to. —*From the Author.*

Forhandlinger i Videnskabs—Selskabet i Christiania, Aar 1863. Christiania, 1864. 8vo.—*From the University of Christiania.*

Chemisk Udersogelse af Mergeller og deri indeholdte Boleer af Th. Hiortdahl. Christiania. 8vo.—*From the Author.*

Om det Syphilitiske Virus, af L. Bidenkap. Christiania, 1863. 8vo. —*From the Author.*

Biblical Natural Science, being the Explanation of all References in Holy Scripture, in Geology, Botany, Zoology, and Physical Geography. By the Rev. John Duns, D.D., F.R.S.E. Two vols. large 8vo.—*From the Author.*

Monday, 3d *April* 1865.

Sir DAVID BREWSTER, President, in the Chair.

The following Communications were read:—

1. On the Food of the Royal Engineers stationed at Chatham. By Dr Lyon Playfair.

The value of the food of soldiers is an important subject, because it presents us with the results of a long experience in feeding adult men, so as to preserve them in health and strength.

In this country fixed rations of $\frac{3}{4}$ lb. meat and 1 lb. of bread are issued to the soldiers, and the rest of their food is furnished

from their own pay. The average diet of soldiers in peace and war is as follows, in ounces and tenths of an ounce :—

		In Peace.	In War.
Flesh formers,		4·2	5·4
Heat givers,	Fat,	1·8	2·4
	Starch, &c.	18·7	17·9
Starch equivalent of heat givers,		22·1	23·5
Total carbon,		12·0	12·7

The peace diet has been obtained by discussions of the food given to the English, French, Prussian, and Austrian armies; while the war diet, in addition to these, includes the Russian, Dutch, Federal States, and Confederates States' armies. Our own country is the only one which does not possess a special war diet, and the want of it told in the frightful mortality of the Crimea. During the latter part of the Russian war, the rations to the English soldiers were increased; but the diet of the English army when engaged in the arduous work of war is, according to the author of the paper, unworthy of the country—twenty years behind the state of science, and a hundred years behind the experience of other nations. To ascertain what well-paid soldiers, engaged in occupations which would represent moderate war work, found it necessary to eat, Dr Playfair obtained returns from the garrison at Chatham. As is well known, the Sappers and Miners are men versed in trades with which they are occupied when not working at fortifications, or in the field. With the permission of Col. Harness, Col. Collinson undertook this inquiry, and obtained the exact food consumed by 495 men for twelve consecutive days. The reduction of these carefully prepared returns is as follows, in ounces and tenths of an ounce :—

Flesh formers,	5·1	Starch equivalent of heat givers,	29·4
Fat,	2·9		
Starch, &c.,	22·2	Total carbon,	14·8

It will be seen that this dietary resembles much the war dietary, except that as potatoes are largely used in garrison, the starch, and consequently the carbon, is increased. The author concludes that a war diet should have as a *minimum* a supply of 5½ ounces of flesh formers in the food. This quantity is necessary to enable

them to march fourteen miles daily, with 60 lbs. weight of accoutrements, without living upon their own tissues to obtain the necessary force.

2. Notice of a large Calcareous Stalagmite brought from the Island of Bermuda in the year 1819, and now in the College of Edinburgh. By David Milne Home, Esq., of Wedderburn.

The author stated that this stalagmite was a calcareous deposit of a columnar shape, which had been brought to Edinburgh, about forty-six years ago, by his father, the late Admiral Sir David Milne.

Whilst commander-in-chief on the North American and West Indian Station during the three years ending 1819, Sir David had passed a part of every winter in the genial climate of Bermuda. He took much interest in the various objects of natural history abounding in the island, and particularly in its remarkable caves.

Possessing some knowledge of geology, and being a personal friend of the late Professor Jameson of the University of Edinburgh, who was then collecting specimens from all quarters for a Museum, Sir David resolved, on the expiry of his command, to bring home with him, besides madrepores and other marine productions, some of the beautiful calcareous deposits from the caves, and present them to the Museum.

These calcareous deposits consist—1*st*, Of crusts of crystallised matter coating the floor, sides, and roof of the caves; 2*d*, Of icicle-shaped formations attached to and pendant from the roof; 3*d*, Of columnar-looking deposits resting on the floor, with broad rounded tops.

These various deposits are formed in the usual way, by water highly charged with lime;—the lime being held in solution by carbonic acid gas contained in the water, and on the escape of that gas, as the water evaporates, the lime is precipitated.

All the requisites for these deposits abound in Bermuda. The rocks of the island (of which a specimen was exhibited) are entirely calcareous, being composed of comminuted fragments of sea-shells and zoophytes. The amount of rain which falls annually on the island, and which percolates through the rocks, is very consider-

able,—whilst the heat of the climate is great; and there are frequently strong parching winds, which promote evaporation.

The different forms of the stalactite deposits are believed to be formed in the following manner:—When the water, after percolating the limestone rock, reaches the roof of the cave, and in such quantity as to drop copiously and rapidly, the evaporation takes place, both during the falling of the water to the floor of the cave and after it reaches the floor. In that case the calcareous matter accumulates on the floor, and if the water continues to drop long enough from the same part of the roof, the deposit gradually rises up in a columnar form. These are the *Stalagmites*.

If, however, the water is less abundant, and the drops less frequent, evaporation takes place whilst they are adhering to the roof. In that case the drops of water thicken on the roof itself into a calcareous paste, and icicle-looking deposits are formed. These are the *Stalactites*.

The two forms of deposit were indicated on a sketch exhibited, and were illustrated by specimens on the table, which Professor Allman had allowed to be brought over from the College Museum.

Much larger specimens, however, of both kinds, had been brought to the Museum,—one of these, a stalagmite, about 6 feet high, now at the door of the Museum. Another, to be more particularly described, was too ponderous to be placed there; it had always lain in the vestibule of the Mathematical Class-Room.

Its length is, ...	11 feet	3 inches.
„ average diameter at the base, .	2 „	1 „
„ girth half-way between base and top,	7 „	4 „

Supposing that there are 44 cubic feet of stone in this stalagmite, and that each cubic foot weighs 170 lbs., the weight would be nearly $3\frac{1}{2}$ tons.

The cave from which this stalagmite was taken is situated at Walsingham, in the parish of Hamilton, and upon the side of a hill, about 40 or 50 feet above the sea, and a quarter of a mile distant from it. The author remembered the cave well, having, with his brother, been in Bermuda with Sir David Milne during his command.

The cave inside might be about 25 or 30 feet high at the greatest height of the roof, about 50 or 60 yards in length, and 20 to 30 yards in breadth. But it is quite irregular in shape. It contains

an immense number of both stalactites and stalagmites of all sizes. Some of the latter had grown up so high as to have reached the roof and become supports to it, and were from 30 to 40 feet in girth.

At the bottom or lowest part of the cave there is a large and deep pool of salt water, rising and falling with the tides,—proving a connection with the sea.

The entrance of this cave is narrow, and about 8 feet high. The floor descends rapidly and irregularly. At the distance of 25 or 30 yards from the mouth stood the stalagmite which forms the subject of the present notice. At this place the floor slopes downwards, and the roof is about 15 feet above the floor, so that the stalagmite had grown up high enough to nearly reach the roof.

This stalagmite, the author's father caused to be sawn across near its point of attachment to the floor. It was first sawn half across, and a nick made with the saw on the opposite side; it was then pulled over, so as to cause fracture, the column having been previously secured by strong tackling and shears to prevent it falling over altogether.

The author's brother, Rear-Admiral Sir Alexander Milne, having been commander-in-chief for the last four years on the North American Station, he also, as their father had done, spent the winter at Bermuda, and when there, paid one or two visits to the cave from which the stalagmite had been taken. He had no difficulty in recognising the trunk, by the evident appearance of its having been sawn across; and he was at once struck by observing that it was again growing, by the accumulation of fresh calcareous matter. It occurred to him that it might be interesting to measure, as exactly as possible, the quantity deposited during the forty-four years which had elapsed since the stalagmite had been removed. With that view he made the following observations:—

He noticed five drops of water falling on the trunk,—two at the rate, each of them, of three or four drops in the minute. The other three dropped much less frequently.

On the part of the trunk where the two first-mentioned drops were falling, two small knobs of calcareous matter had been formed.

On the part of the trunk where the three last-mentioned drops were falling, the deposit consisted of only a thin crust.

One of the knobs measured in height above the fractured surface five-eighths of an inch, and had at its base an area of about $3\frac{3}{4}$ inches in diameter. The other knob measured in height four-tenths of an inch, and had at its base an area of about $2\frac{1}{4}$ inches.

Supposing these knobs to be exact cones, there would be 2·3 cubic inches in the former, and ·53 cubic inches in the latter,—making altogether 2·83 cubic inches. But as the tops were rounded, one-third should be added to this result,—making altogether 3·77 cubic inches. With regard to the amount of matter deposited by the three remaining drops, it was scarcely appreciable, so that the cubic contents of the whole deposit may be very safely assumed as not having exceeded five cubic inches.

Such having been the amount of growth of the stalagmite during forty-four years, it occurred to inquire how long, at the same rate of growth, it had taken for the whole stalagmite to be formed. In the part of it now at the College, to say nothing of the contents of the trunk still in the cave, there are 44 cubic feet, or above 76,000 cubic inches. If this amount of calcareous matter had been deposited at the same rate as the 5 cubic inches during the last forty-four years, the whole stalagmite would have required the astounding and incredible period of more than 600,000 years for its formation.

There are several circumstances, however, deserving of notice, which show how little such a calculation is to be relied on,—though at first sight it is perhaps quite as plausible as many other calculations of a similar kind.

It assumes that during the whole time of the formation of the stalagmite, the calcareous matter had been deposited at exactly the same rate as during the last half-century; in other words, that the supply of calcareous water to this part of the roof had been always exactly the same. There is, however, nothing to prove that this was the case;—it is, moreover, not in the least likely to be true. Indeed, the great probability is, that the supply of water to any one spot in the roof would be much greater at first than afterwards. The porous limestone rock of Bermuda becomes hardened and encrusted by the rain-water percolating through or over it, and the rapidity of this process was marvellous. Lieut. Nelson of

the Engineers,* when he was superintending the excavations in Bermuda for the dockyard, found the eggs and bones of a sea-fowl, one of the existing species which lays its eggs in crevices of the rocks, entombed in the coarse limestone rock. The poor bird, whilst sitting on its nest, had been caught by some storm of sand which filled up the crevice, and the prisoner, with its eggs, became petrified and encased in the rock. Many examples of the same kind had come to Lieut. Nelson's knowledge. He found a canister-shot and a gold knee-buckle similarly fossilised. Wherever the limestone rock has been exposed to the weather, it gets encrusted with crystallised stalagtitic matter, so that in any place where a hollow or trough occurs on the surface of the rock, water falling or flowing into it, stands. In these circumstances it is not difficult to see how water, filtering at first through to the roof of a cave, might, in the course of time, have its course diverted from the spot where it used to drop abundantly, or at all events, how it should diminish in quantity. It is therefore reasonable to infer, that in the early history of the caves, the water flowed through the roofs much more copiously than afterwards. The cracks and interstices in the porous rock would become gradually filled up, so as to cut off or curtail the flow of water, and consequently lessen the supply of calcareous precipitate.

On these grounds the author entirely repudiated the notion that this stalagmite had taken the enormous period to grow, indicated by the foregoing calculation,—though what period it actually did take, there were no data to determine.

In concluding, the author referred to the probable origin of these caves. He considered that they had originally consisted of great masses of loose sand which had become enveloped in compact limestone. Lieut. Nelson, in his paper describing the excavations for the dockyard, mentioned that "the irregular density of the rock is exhibited on all scales, from minute flaws and patches, to *large masses of dry sand*, which more than once occurred during the progress of our excavations in the heart of otherwise hard, sound rock." He says that these beds of dry sand lay just above the level of high water, and were "covered by cliffs of good rock sometimes

* Geological Society Transactions for 1837, vol. v.

50 *feet high.*" The extent to which shelly sand was thrown up by the waves on the shores of the island, and then blown by the S.W. winds, so as actually to form hills of 180 feet in height, had been described by Lieut. Nelson, and the author himself distinctly remembers them, along the south side of the island. It seemed probable that the rain-water, containing as it does a certain amount of carbonic acid gas, had, by percolating through the sand-dunes in ancient times, hardened and consolidated the calcareous sand, down to a certain depth, into solid rock; and this result would be all the more likely if, at a former period of the earth's history, as many geologists supposed, the earth's atmosphere then contained a larger proportion of carbonic acid gas. The compact limestone rock having been formed in this way, enclosing and lying above huge masses of sand, it was suggested that in the course of time the sand had been undermined and washed out by the action of the sea. It was understood that every one of the Bermuda caves are at or near the sea-level, and have pools of salt-water in them.

3. Meteorological Observations on Storms of Wind in October, November, and December of 1863. By Alexander Buchan, M.A., Secretary to the Scottish Meteorological Society.

The author had traced eleven distinct storms of wind passing over parts of Europe, between the 26th October and 18th December. With the view of ascertaining the state of the atmosphere during the progress of these storms, in respect of pressure, temperature, wind, cloud, and rain, he had collected observations from all parts of Great Britain and Ireland, as well as from many places on the Continent. He found that each storm was marked by concentric circles of equal atmospheric pressure. Generally, the point of greatest barometric depression was 28·5 inches, round which, as a centre, the isobarometric lines could be traced up to 30 inches.

These isobarometric lines, especially when near the central area of minimum pressure, were often circular, or nearly so;—when they were elliptic, the longer axis generally coincided with the direction in which the storm moved.

In the great majority of the cases investigated, the storm moved

towards some point of the quadrant between north-east and south-east. In one case the movement had been from the north-east; but this had soon receded or disappeared, apparently absorbed by a new storm from the south-west.

The observations on temperature indicated that before a storm from south-westward reached a place, the temperature rose, and after it had passed, the temperature fell at that place.

The direction of the wind in the storm was ascertained to be pretty nearly coincident with tangents to the isobarometric curves, though with a tendency to turn inwards towards the centre. The author considered that he had established that all storms marked by a low barometer, and moving north-easterly, rotated from right to left, looking northwards.

With regard to the violence of the winds, he found that it was greatest where the isobarometric curves (having each a difference of two-tenths of an inch) were closest to each other;—when these lines, whether of high or of low pressure, were far apart, the wind was moderate.

4. On the Use of Graphic Representations of Chemical Formulæ. By Dr A. Crum Brown.

The idea of atomicity, or the definite equivalence of chemical atoms, is the necessary consequence of the theory of replacement. It was employed by Frankland to explain the nature of the organo-metallic bodies, and its application was further extended by Kolbe to a large number of organic substances.

It is, however, to Kekulé that we owe the complete generalisation of this idea and its systematic application to all classes of compounds. This first rendered it possible to represent, as it is often advantageous to do, the constitution of compounds by completely dissected formulæ. The most convenient way of doing this is to employ some suitable system of graphic notation.

Kekulé himself, in his "Lehrbuch," made use of a system which has the advantage of compactness and clearness, but is limited in its application to those compounds in which the poly-atomic atoms form a single chain. In order to obviate this inconvenience, I proposed, in my thesis presented to the Medical Faculty

of the University in 1861, a form of graphic notation which, while inferior in compactness to that of Kekulé, appears to me preferable, as being at least equally clear and applicable to every formula in accordance with the theory of atomicity.

In an able and suggestive paper published in the "Bulletin de la Société Chimique de Paris" for February 1865, Kekulé uses a modification of his original notation, which to a great extent removes my first objection to it, but at the same time lays it open to another and more serious one—that of obscurity and ambiguity. That this is not an imaginary or trivial defect is made evident by the circumstance that Kekulé has himself, in the paper referred to, been led into an error by his notation. In a foot note, pp. 103 and 104, he says:—"On conçoit cependant au point de vue de la théorie de l'atomicité l'existence d'une categorie d'alcools, dont la constitution devra être exprimée par les noms que je viens de citer. [Alcool méthylo-éthylique, éthylo-méthylique et diméthylo-méthylique.] C'est cette categorie d'alcools dont la sagacité de M. Kolbe a prévu l'existence. La différence entre ces alcools et l'alcool propylique normal est assez clairement rendue par les figures 27 et 28.

Il ne faut cependant pas confondre avec ce genre d'alcools isomériques les pseudo-alcools que résultent de la réduction des acétones et que se rattachent évidemment aux acétones mêmes (figs. 29 et 30).

Il ne faut pas confondre non plus les pseudo-alcools additionnels que M. Wurtz a dérivés des hydrocarbures; c'est une isomérie d'un ordre tout à fait différent," &c. The figures referred to are—

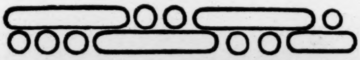


Fig. 27. Alcool Propylique.

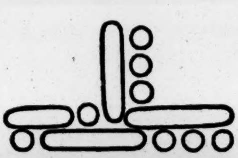


Fig. 28. Alcool Méthyle-éthylique.

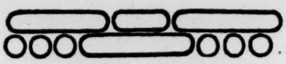


Fig. 29. Acétone.

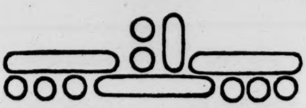


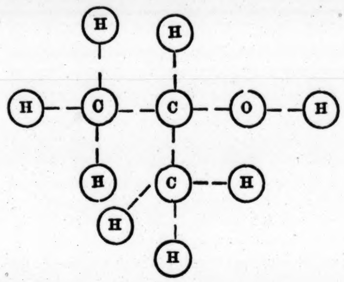
Fig. 30. Alcool Acétonique.

Now if we translate those formulæ into any other system capable of

indicating the chemical position of each atom, we find that figs. 28 and 30 are identical. In Butlerow's formulæ, we have

$$\left.\begin{array}{l} CH_3 \\ CH\,(HO) \\ CH_3 \end{array}\right\} \text{ or typically } C \left\{\begin{array}{l} CH^3 \\ CH_3 \\ H \\ (HO) \end{array}\right.$$

or, on the graphic system which I use,



In fact, a little consideration will show that the theory of atomicity does not admit of more than two substances having the formula $C_3H_7\,(HO)$. In reference to the last sentence quoted from Kekulé, I shall only remark that his view is not borne out by fact in the case of hydrate of propylene, as Berthelot has shown that it is identical with the alcohol derived from acetone.

The following Gentlemen were elected Ordinary Fellows of the Society:—

1. James Powrie, Esq., F.G.S.
2. Charles Jenner, Esq.

The following Donations to the Library were announced:—

Bulletin de l'Académie Royale des Sciences, des Lettres, et des Beaux Arts de Belgique, Nos. 1, 2. Bruxelles, 1865. 8vo.—*From the Academy.*

Proceedings of the Royal Geographical Society. Vol. IX., No. 2. London, 1865. 8vo.—*From the Society.*

Proceedings of the British Meteorological Society. Vol. II., No. 17. London, 1865. 8vo.—*From the Society.*

The Journal of the Chemical Society, February 1865. London, 1865. 8vo.—*From the Society.*

Visible Speech: A new Fact demonstrated. By Alexander Mel-

ville Bell, F.E.I.S., &c. Edinburgh, 1865. 12mo.—*From the Author.*

Abhandlungen der Koniglichen Akademie der Wissenschaften zu Berlin, 1863. Berlin, 1864. 4to.—*From the Academy.*

Verzeichniss der Abhandlungen Gelehrter Gesellschaften und der Wissenschaftlichen Königl. Preussischen Akademie der Wissenschaften zu Berlin. Berlin, 1864. 8vo.—*From the Academy.*

Lawson's Pinetum Britannicum. Part VIII. Elephant Folio.—*From the Right Hon. The Lord Provost.*

Monday, 17*th April* 1864.

LORD NEAVES, V.P., in the Chair.

The following Communications were read:—

1. On Confocal Conics. By H. Fox Talbot, Esq.

2. On the Celtic Topography of Scotland. By W. F. Skene, Esq.

The author commenced by distinguishing between an etymology of names of places founded upon mere resemblance of sounds, and one where the names are analysed according to fixed laws, based upon sound philological principles and a comprehensive observation of facts. The former is the ordinary process to which they are subjected, and has characterised all systematic attempts hitherto made to analyse the topography of Scotland. It can lead only to fanciful renderings, and is incapable of yielding any certain results, while the latter becomes an important element in fixing the ethnology of the inhabitants of a country. Names of places undergo a process of change and corruption. The language from which they were derived has likewise gone through a process of change and decay, and an interpretation based upon mere resemblance of sounds, in the present form of the names of places, to words in an existing language, ignores this fact and can only mislead. In order to obtain a sound etymology it is necessary to ascertain the old form of the name, and to analyse it in conformity with the phonetic laws of the language from which it sprung.

The author then showed the fallacy of the system of phonetic etymology, on which the conclusions of Pinkerton, Chalmers, and others were based, and that the attempts hitherto made to discriminate between that part of the population speaking a Kymric, from that speaking a Gaelic dialect, from the topography of the districts, was founded upon an inaccurate conception of the facts and a false view of the dialectic differences. In especial, he showed that the attempt to draw a line of demarcation between them from the respective prevalence of the terms Aber and Inver, was founded upon an incomplete and inaccurate apprehension of the real facts of the case, and was not borne out by the actual topography of the country.

The author then explained a table he had prepared, showing the geographical distribution of a complete list of the terms which enter into the Celtic topography of Scotland. This table showed the number of times that each term occurred in Ireland or in Wales, and likewise in every county of Scotland, and to a great extent disproved the assumed facts upon which the deductions usually made from the topography, are based.

This table likewise showed that there were four terms peculiar to the districts inhabited by the Picts, and these words belonged to the Gaelic and not to the Kymric branch of the Celtic.

The author then showed that some of the terms belonged to an older form of the language than others, and after giving examples of this, he concluded by stating the following as the results of his investigation :—

1. In order to draw a correct inference from the names of places as to the ethnologic character of the people who imposed them, it is necessary to obtain the old form of the name before it became corrupted, and to analyse it according to the phonetic laws of the language to which it belongs.

2. A comparison of the generic terms affords the best test for discriminating between the different dialects to which they belong, and for this comparison it is necessary to have a correct table of their geographical distribution.

3. Difference between the generic terms in different parts of the country may arise from their belonging to a different stage of the same language, or from a capricious selection of different

synonyms by different tribes, as well as from a real dialectic difference between the languages from which they were derived.

4. In order to afford a test for discriminating between dialects, the generic terms must contain within them those sounds which are differently affected by the phonetic laws of each dialect.

5. Applying this test, the generic terms in Scotch topography do not show the existence of a Kymric language north of the Firths of Forth and Clyde.

6. We find in the topography of the north-east of Scotland traces of an older and of a more recent form of Gaelic. The one preferring labials and dentals, and the other gutturals. The one hardening the consonants into *tenues*, the other softening them by aspiration. The one depositing Abers and Invers simultaneously, the other Invers alone. The one a low Gaelic dialect, the other a high Gaelic dialect, the one probably the language of the Picts, the other that of the Scots.

3. On the Bands produced by the Superposition of Paragenic Spectra formed by the Grooved Surfaces of Glass and Steel. Part II. By Sir David Brewster, K.H., F.R.S.

4. Remarks on the Flora of Otago, New Zealand. By W. Lauder Lindsay, M.D., F.L.S., Hon. Member of the Philosophical Institute of Canterbury, New Zealand.

The North Island flora has hitherto been regarded (in the absence of a knowledge of the South Island flora) as representing the general vegetation of our New Zealand possessions. But the New Zealand Islands extend through thirteen degrees of latitude, and the floras of their northern and southern extremes necessarily present various marked differences. The former flora is more subtropical, and the latter more antarctic in its affinities. The former, morever, is richer in natural orders, genera, and species.

Until very recently, however, comparatively little or nothing was known of the Otago flora, all collections previous to 1861 having been made on its coast, and with a single limited exception on its

western coast. In 1861 the author botanically examined the vicinity of Dunedin, and the settled districts between that capital and the Clutha River,—all on the eastern sea-board of the province. The immediate fruit of this examination included, in the department of phænogams and ferns alone, a total of 235 species.

Five species were new to science, viz., *Viscum Lindsayi* (Oliv.), parasitic on *Metrosideros hypericifolia*, *Celmisia Lindsayi* (Hook. fil.), *Poa Lindsayi* (Hook. fil.), *Aciphylla Colensoi* (Hook. fil.), and *Crepis Novœ Zelandiœ* (Hook. fil.) (Drawings of these plants were exhibited.)

Five species had not been previously found in New Zealand; twenty-two had not been previously found in Otago thirty were rare in Otago; and twenty-five species indigenous in Otago were British.

In addition to these and to the total of 235 species, there were twenty-seven species of British plants naturalised in Otago, making a total of 262.

Between 1862 and 1864, the interior of Otago has been explored by the Government Geological Survey, and the collections made by the botanist attached thereto have largely added to our knowledge of the flora, more especially of its western alps and great central lake basins.

The author in his paper (which refers only to Phænogams, Ferns, and their allies) endeavours to give the great characteristics of the flora of Otago, as a type more especially of the southern flora of New Zealand, and he draws a comparison between the flora of the south and of the north. The subject is treated mainly in a tabular and statistical manner.

The following table shows the numerical strength of the Phænogamic Flora of Otago :—

I. PHÆNOGAMS.

†Dicotyledons.

	No. of Orders.	No. of Genera.	No. of Species.
A. *Angiospermœ*—			
1. Thalamifloræ, ...	12	27	53
2. Discifloræ, ...	5	5	7
3. Calycifloræ, ...	13	38	98

	No. of Orders.	No. of Genera.	No. of Species.
4. Corolliflorae, ...	17	53	178
5. Incompletæ, ...	7	14	30
	54	137	366
B. *Gymnospermæ*, ...	1	4	10
Total Dicotyledons, . .	55	141	376
††Monocotyledons.			
1. Petaloideæ, ...	6	26	49
2. Glumaceæ, ...	3	31	70
Total Monocotyledons, .	9	57	119
Total Phænogams, . .	64	198	495
II. CRYPTOGAMS.			
1. Filices, ...	1	24	88
2. Lycopodiaceæ and Marsileaceæ, .	2	3	8
	3	27	96
Total Phænogams and Ferns in Otago,	67	225	591

Proportion of species to a genus, 2·61 to 1.

Do. do. natural order, 8·82 to 1.

Do. Dicotyledons to Monocotyledons, 3·15 to 1.

Number of natural orders containing only *one* genus, 26.

Number of genera containing only *one* species, 104.

The author then enumerates the prominent orders and genera, mentions the proportion of ligneous species, and gives a sketch of the geographical distribution of the plants of Otago under the groups Endemic, Australian, Antarctic, South American, Polynesian, and Cosmopolite (including British plants and widely distributed species).

5. On the Composition of some Old Wines. By Douglas Maclagan, M.D., Curator Roy. Soc. Edin.

The samples of wine were furnished to Dr Maclagan by the Earl of Dalhousie; they had been found in a recess in a wall in Panmure House, which was known to have been built up in 1715; the samples were consequently at least 150 years old.

The wines submitted to examination were three in number, and were contained in quart bottles, resembling those ordinarily in use at the present day. They were, when sent to Dr Maclagan, securely corked; evaporation had, however, gone on to a sensible extent in two of the bottles, the third being nearly full.

No. 1.—Bottle No. 1 contained 21 fluid ounces of wine, its capacity being 25 fluid ounces. The fluid was carefully decanted, and thus separated from a considerable quantity of dark red apothema.

The fluid separated by decantation was slightly turbid, the turbidity not disappearing on filtration. Its colour was a pale tawny brown. It possessed a distinct vinous aroma, which when the bottle was first opened, resembled very closely that of claret. In addition to the vinous, there was a distinctly acetous odour. Its density at 60° Fahr. was 995·42.

The acids of the wine were separated by precipitating first with ordinary, and then with basic acetate of lead, and decomposing the separate precipitates by sulphuretted hydrogen, and testing. The wine was found to contain tartaric and tannic acids, besides sulphuric and phosphoric acids and chlorine in a state of combination. It contained no racemic acid.

The results of a quantitative analysis were the following:—

Water in 1000 parts,	918·414
Alcohol,	70·000
Acetic acid,	3·906
Tartaric acid,	3·187
Sugar,	·654
Soluble salts,	1·672
Insoluble salts,	1·330

In the above analysis the total acidity of the wine was determined by means of a standard alkaline solution; the fluid having

then been acidified with sulphuric acid, was distilled. The acidity of the distillate was then determined by means of the standard alkaline solution; from the amount of alkali used in the second determination, the acetic acid was determined, it being assumed that this was the only volatile acid present. By subtracting the amount of alkali required to neutralise the volatile acid, from the total amount required to neutralise the wine, was found the amount of alkali required to neutralise the fixed acid. The calculation was made on the assumption that the only fixed acid present in the wine was tartaric acid. The assumption is an erroneous one, but was adopted, so that the analysis might compare with other wine analyses, which are usually conducted on this plan.

The sugar was determined in the wine which had been treated with acetate of lead, and subsequently with sulphuretted hydrogen, by boiling with Fehling's solution, and determining by the balance the amount of copper reduced.

The sediment (apothema) of the wine was examined, and found to contain much tannic acid, in combination with the red colouring matter of the wine, besides tartrate of potash.

No. 2.—The bottle was full to the neck of a wine having the unmistakable flavour, and average colour, of Madeira. Though it was very acid, it was by no means undrinkable. Its density at 60° Fahr. was 989·7.

It contained a trace of tannin, but no tartaric acid. The amount of sulphuric acid and chlorine which it contained appeared to be unusually large.

Its complete examination has been prevented by other, and more important, work. The following particulars have been, however, ascertained:—

Total solids in 1000 parts,	27·625
Salts,	2·446
Alcohol,	100·000
Acetic acid,	1·290

Fixed acid, equivalent to 2·152 parts of caustic soda.

The amount of sugar which the wine contained was not determined.

No. 3.—The bottle was full to the shoulder of a turbid, deed

brown wine, of very sour taste, and having the flavour of port. It contained an abundant red deposit.

Its density at 60° Fahr. was	994·06
Total solids in 1000 parts, ...	19·66
Salts, ...	2·79
Alcohol, ...	50·00

The total amount of free acid in 1000 parts was determined by means of a standard solution of soda, and found to be equal to 5·37 parts of caustic soda. The amount of acetic acid was not separately determined. This wine contained a very large quantity of tannic acid still in solution, besides the large amount which had been precipitated in combination with red colouring matter. It contained no tartaric acid in solution. The exact amount of sugar was not determined; it was, however, decidedly small.

6. Preliminary Note on the Colouring Matter of *Peziza æruginosa*. By Dr A. Crum Brown.

The *Peziza æruginosa* is a fungus belonging to the family Ascomycetes, and order Elvellaceæ. Although the fructification is not often met with, the plant itself is by no means rare, growing on dead wood, chiefly of the oak, birch, and ash. It has an intense green colour, and tinges the wood on which it grows to a considerable depth.

The raw material upon which my investigations were made was derived partly from the plant itself, but to a much larger extent from the wood upon which it had grown, or was growing.* I am indebted for the wood and the plants to Dr Alexander Dickson, at whose suggestion I undertook this research.

As Dr Dickson had observed that the colouring matter dissolves without apparent change in the strong mineral acids, but is sparingly soluble in dilute acids, I employed the following method for its isolation:—

The wood, broken into small pieces, was placed in a large funnel,

* In order to determine with certainty the connection between the green wood and the Peziza, Mr M'Nab of the Botanic Garden exposed pieces of the wood, which showed no trace of the fructification, to heat and moisture, when large crops of the fungus were obtained.

containing a small asbestos filter, and the funnel was filled with strong commercial nitric acid. The acid was completely saturated, after passing two or three times through the wood. The solution had a dark-green colour by reflected, and a deep-purple red by transmitted, light. When poured into water, a copious but extremely light flocculent precipitate, of a bright-green colour, was produced, which slowly subsided, leaving the supernatant liquid nearly colourless. As this precipitate was found to possess the same properties, whatever acid was used in its preparation, I had no hesitation in using nitric acid, which is by far the best solvent. On attempting to wash the precipitate with distilled water, either by decantation or on a filter, I found that, while nearly insoluble in moderately dilute acid, it dissolves to a considerable extent in water, even when the latter contains distinct traces of acid. I therefore had recourse to the method of dialysis to get rid of the acid.

The acid liquid containing the green matter in suspension was placed on a dialysor, consisting of a sheet of parchment paper, stretched over a double ring of gutta-percha, and floating in a vessel containing distilled water. After two or three days (the water being frequently renewed) the nitric acid was found to be entirely removed, and the contents of the dialysor consisted of a green liquid, and a dark-green precipitate. The latter left a small white ash on ignition; and as the quantity of ash bore no constant relation to the quantity of green matter, it was obvious that the substance was still impure. In order to purify it further, I took advantage of its solubility in alkalies, and dissolved it in the smallest possible quantity of very dilute ammonia. The brown solution thus obtained was filtered, allowed to stand several days in the dialysor, and precipitated by means of hydrochloric acid. The acid was as removed by dialysis, and a green liquid and precipitate obtained before. This was dried *in vacuo* over sulphuric acid.

The substance thus obtained is a very light powder, almost black when viewed in mass, dark bluish-green when finely divided, and is probably nearly pure. I have, however, not yet analysed it, as it still leaves a decided trace of ash; and I am unwilling to expend the small quantity at my disposal until I have made further efforts to obtain it in a state of purity.

As before stated, the substance dissolves readily in the strong mineral acids, and to a considerable extent in glacial acetic acid. These solutions are precipitated by water. It also dissolves in water and chloroform. All these solutions are green. It is insoluble in alcohol and ether. It is soluble with a brown colour in alkaline solutions. When no excess of alkali has been used, these solutions are precipitated green by dilute acids; but when allowed to stand, even for a few minutes, with excess of alkali, they undergo a change, and acids then produce a slimy-brown precipitate. The same change takes place when the aqueous or alkaline solution is heated to 100° Cent.

The neutral ammonia solution gives precipitates of a dirty green or brown colour with most metallic solutions.

When the substance is fused with dry caustic potash, a powerful ammoniacal odour is given off: It therefore contains nitrogen.

These observations lead to the conclusion that the substance is a weak acid, and that it forms compounds of slight stability with the stronger acids. Any speculations as to its nature are, however, premature, until we obtain analyses of the body itself, and of some of its compounds.

Since writing this note, I have observed in the "Comptes Rendus," vol. lvii. p. 50, a paper by M. Fordos, apparently on the same subject. M. Fordos was not aware of the origin of the green colour, and seems to have obtained only a very small quantity of it. He has anticipated me in the observations as to its solubility in strong acids and chloroform, and has proposed for it the name of "Acide xylochloerique."

7. On the Motion of Interpenetrating Media. By Alfred R. Catton, B.A., Assistant to the Professor of Natural Philosophy in the University of Edinburgh.

The following Gentlemen were balloted for, and elected Fellows of the Society:—

1. Charles Lawson, junior, Esq.
2. Alex. Keiller, M.D., F.R.C.P.E.

The following Donations to the Library were announced:—

Journal of the Statistical Society of London. Vol. XXVIII., Part 1. 8vo.—*From the Society.*

Journal of the Chemical Society. Vol. III., No. 27. London. 8vo.—*From the Society.*

Proceedings of the Royal Society, London. Vol. XIV., No. 73. 8vo.—*From the Society.*

American Journal of Science and Arts. No. 116. New-Haven. 8vo.—*From the Editors.*

Monthly Return of the Births, Deaths, and Marriages registered in the Eight Principal Towns of Scotland, March 1865. 8vo.—*From the Registrar-General.*

Seventh Detailed Annual Report of the Registrar-General of Births, Deaths, and Marriages in Scotland. Edinburgh, 1865. 8vo.—*From the Registrar-General.*

On the Malacostraca of Aristotle. By J. Young, M.D., F.R.S.E. 8vo —*From the Author.*

On some of the more Important Diseases of the Army; with Contributions to Pathology. By John Davy, M.D., F.R.S. London, 1862. 8vo.—*From the Author.*

Physiological Researches. By John Davy, M.D., F.R.S. London, 1863. 8vo.—*From the Author.*

Mémoires de la Société de Physique et d'Histoire Naturelle de Genève. Tome XVII., Pt. 2. Genève, 1864. 8vo.—*From the Society.*

Denkschriften der Kaiserlichen Akademie der Wissenschaften. Mathematisch-naturwissenschaftliche Classe, Band XXIII. Philosophisch-historische Classe, Band XIII. Wien, 1864. 4to.—*From the Academy.*

Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften. Philosophisch-historische Classe, Band. XLV., Hefte ii., iii.; Band XLVI., Hefte i.–iii. Mathematisch-naturwissenschaftliche Classe (Meteorologie), Band XLIX., Hefte ii.–v. (Mineralogie), Band XLIX., Hefte ii.–v.; Band L., Heft i. Wien. 4to.—*From the Academy.*

Almanach der Kaiserlichen Akademie der Wissenschaften. Wien, 1864. 8vo.—*From the Academy.*

Abstracts of the Proceedings of the Geological Society of London, Nos. 130, 131. 8vo.—*From the Society.*

Journal of the Society of Arts, Weekly, for 1864–65. London. 8vo.—*From the Society.*

Comptes Rendus Hebdomadaires des Seances de l'Académie des Sciences. Paris, 1864–65. 4to.—*From the Academy.*

Monday, 1st May 1865.

PROFESSOR CHRISTISON, V.P., in the Chair.

The following Communications were read:—

1. Some Observations on the Cuticle in relation to Evaporation. By John Davy, M.D., F.R.S. Lond. & Edin.

In this paper the author gives an account of many experiments made on the loss of weights of different animals in their fresh state, when suspended, exposed to the air, from evaporation; from the results of which he infers, that it is comparatively greatest from the batrachians, not quite so great from fishes, less from mammalia, and least from birds.

Physiologically considered, he infers that the function, in all but the fishes, is connected with the regulation of animal heat, tending to keep the cool-blooded batrachians cool, and birds of a high temperature warm.

Viewed pathologically, he shows how it tends to prevent inspissation and drying, and to preserve the blood in a healthy, and the tissues in a flexible, moist state.

In addition, he gives an account of some similar trials on vegetables, in which the cuticular covering performs a part in relation to the retarding of evaporation and the preservation of life, similar to that which it exercises on animals.

He concludes with calling attention to the drying of meats and vegetables in an economical point of view, and with the expression of regret that these in their dried state—so much used in the United States of America, and on the Continent, and so easily obtained, considering the simplicity of the process, are not more used in Great Britain, especially by the labouring class.

2. On Water, Hydrogen, Oxygen, and Ozone. By John Macvicar, D.D. Communicated by Dr E. Ronalds.

3. Note on the Behaviour of Iron Filings, strewn on a vibrating plate, and exposed to the action of a magnetic pole. By Professor Tait.

While a horizontal plate is in a state of rapid vibration (as in Chladni's experiments), iron filings strewed on the surface, near a point of maximum vibration, are prevented from being scattered to the nodal lines by a magnetic pole held *above* the plate, but, if the pole be held *below*, they are speedily dissipated. If too powerful a pole be used, or if the magnet be held too near the plate, the filings nearest to the pole are not dispersed in the latter case. I mention this curious fact (which was observed recently by Mr Talbot and myself), on account of its explanation, which is very simple.

The filings tend to place their greatest length in the direction of lines of magnetic force; and thus, when the pole is above the plate, their upper ends incline inwards to it, so that the agitation of the plate, combined with the magnetic attraction, brings them nearer to the point immediately below the pole. When the pole is below the plate, the upper ends of the filings diverge *from* the pole, and the agitation sends them outwards, unless the magnetic attraction be considerable.

4. On some Congenital Deformities of the Human Skull. By Wm. Turner, M.B., F.R.S.E.

1*st*, *Scaphocephalus.*—After making reference to his previous papers,* more especially to that in which he had described several specimens of the scaphocephalic skull, in which he had discussed the influence exercised on the production of deformities of the cranium, by a premature closure or obliteration of the sutures, and to the recent memoirs of Professor von Düben of Stockholm,†

* Natural History Review. January 1864, and January 1865.

† Medicinskt Archiv. Stockholm. Vol. ii. Part i. p. 1. 1864.

and Dr John Thurnam,* the author proceeded to relate two additional cases of scaphocephalus to those he had already recorded. He had met with one of these in the head of a living person, the other in a skull in the Natural History Museum of the University of Edinburgh.

The first case occurred in a young man, a native of Scotland, and was a very characteristic specimen. The great elongation and lateral compression of the skull in the parietal region were well exhibited, the sagittal ridge was strongly pronounced, and the flattening of the skull on each side of the ridge was considerable. The head was 9 inches long; and this great elongation was chiefly displayed in the bulging backward of the occipital region, for there was no marked projection of the forehead. The characteristic shape of this youth's head was congenital, for it had been observed from his earliest infancy, and his birth was attended with considerable difficulty. He was of studious habits, and very intelligent. For in these cases of scaphocephalism there is not necessarily any intellectual deficiency, as the impeded growth of the skull in the transverse direction from early obliteration of the sagittal suture is compensated for by the increased growth in the antero-posterior, and the growth of the brain though restricted in one direction is permitted in another. Hence, the cubic capacity of these crania does not seem to be below the mean of the race or races in which they have been found; one of the skulls the author had formerly described—117 *a*, Edinburgh University Anatomical Museum—having a capacity as high as 108 cubic inches.

The skull in the Natural History Museum is that of an Egyptian mummy, and was described and figured as such by the late Mr Andrew Fyfe, in his "Illustrations of the Anatomy of the Human Body." † He states, that "it is remarkable, not only for its length and narrowness, but for the strong impression made by the temporal muscle, and for the sharpness of the arches of the forehead and occiput;" but he says nothing of the condition of the sagittal suture, and apparently regards the skull as a characteristic specimen of the ancient Egyptian cranium. Conjoined, however, with this

* Natural History Review. April 1865.

† Third Edition. Plates vii. A. and vii. B. Edinburgh, 1814. And in Table viii. page 8, of the edition published in 1830.

length and narrowness are an absence of parietal eminences, a complete obliteration of the sagittal suture, a keel or ridge along the sagittal line, and such a complete blending of the two parietal bones, that it must be pronounced to be a typical specimen of the scaphocephalic skull. Hence it cannot be regarded as expressing the normal form of head of the ancient Egyptian, but simply as an individual peculiarity due to premature closure of the sagittal suture, and possessing no ethnological value. For skulls of this form may apparently occur in any race, and in any clime, as well in the old Egyptian as in the Scotchman of the present day.*

As minor characters in this cranium, may be noticed, that the lateral, longitudinal, and vertical transverse lines of sutures are marked externally, but probably obliterated internally. The forehead is rounded and projecting in the region of the frontal eminences, but behind these tubera the frontal bone has a roof-like form. The biparietal bone has no beak jutting forward into the frontal, and there are indications of the former presence of parietal foramina. A narrow beak runs forward from the superior angle of the occipital bone into the biparietal bone. The facial bones are broken away, and the cavity of the skull is full of a black bituminous-like material. The skull is apparently that of a person past the middle period of life, but whether male or female is somewhat uncertain, though it is probably the latter.

The following are some of the principal measurements, expressed in inches and tenths:—

Extreme length, 8·1; breadth, 4·8; height, 5·3.
Greatest frontal breadth, 3·9; parietal, 4·3; occipital, 3·6.
Frontal radius, 4·8; parietal, 4·7; occipital, 4·3.
Frontal arc, 5·4; parietal, 6·2; occipital, 4·9; longitudinal, 16·5.

* Upwards of forty cases of scaphocephalism have now been recorded by the following anatomists:—Sandifort, Blumenbach, and Von Baer, each one; Virchow and Lucae, each two; Minchin, three; Welcker, four; Von Düben, seven; Thurnam, nine, and the author, including the two cases described in the text, eleven; and they have been found in English, Scotch, Irish, French, German, Danish, Swedish, Croatian, Illyrian, Tartar, Gentoo, Esquimaux, Ancient Egyptian, Negro, and Australian heads.

Frontal transverse arc, 12·6; parietal, 12·0; occipital, 10·6. Circumference, 21·3.

2*d*, *Congenital Deficiencies in the Cranium.*—For the opportunity of examining the very remarkable skull-cap next described, the author was indebted to Professor Maclagan, who, on account of some circumstances connected with the death of the person to whom it belonged, possessing a medico-legal interest, had had it sent him by Dr T. J. Maclagan of Dundee.* The skull-cap was from a woman æt. 25. In the inter-parietal part of the occipital bone an oval opening, with a smooth rounded margin, existed in the middle line. Its long axis was vertical, and measured one inch; its transverse diameter was a little more than half an inch at the widest part. A suture extended upwards from the upper end of this opening in the middle line, as far as the superior angle of the bone. This hole was, in the recent state, filled up by a membrane. In the posterior slope of each parietal bone an oval opening, with a rounded margin, was situated. The long axis of each was transverse; that on the right side $\frac{8}{10}$ths, that on the left $\frac{6}{10}$ths of an inch long; whilst the antero-posterior diameter on the widest part, on the right side, was $\frac{6}{10}$ths, on the left $\frac{4}{10}$ths of an inch. These openings were filled up in the recent state with a cribriform membrane. A suture passed from the inner end of the left parietal opening almost transversely inwards for about half an inch, when it reached the middle line, and then extended downwards and backwards for 1¼ inch, as far as the lambdoidal suture, occupying the position of the posterior part of the sagittal suture. The right parietal opening had no suture proceeding from it, though there were appearances as if one had formerly existed. The parietal openings by their outer ends were close to elevations in the bones, which evidently corresponded to the parietal tubera.

The inner surface of the skull-cap, in front of the parietal openings, was marked by the groove for the superior longitudinal sinus along the middle line; opposite these apertures it was deflected, and ran close to the inner end of the right parietal opening; and preserving this direction it ran along the right side of the occipital opening as far as the internal occipital protuberance; from the

* Proc. Med. Chir. Soc. Edin. in Edinburgh Medical Journal, May 1865.

inner end of the left parietal opening a shallow groove proceeded, which ended in the groove for the superior longitudinal sinus, and had apparently, at one time, lodged a small venous sinus. Anteriorly, the right parietal bone sent forward into the frontal a beak similar to those the author had described in some of the scaphocephalic crania recorded in his former paper. Traces of a suture, visible only externally, might be seen commencing at the coronal suture, immediately to the left of the base of the beak. It extended in an interrupted manner backward for about an inch and a half, and then disappeared, so that from this spot, to a point midway between the two parietal openings, the sagittal suture was entirely obliterated, and the two parietal bones were completely blended together. The other sutures of the skull-cap were well marked, both internally and externally.

The author then discussed the probable modes of production of these malformations. He argued that the opening in the occipital bone was due to want of union in the middle line of the ossific spicula proceeding from the two centres of ossification from which the inter-parietal, or cerebral, part of the occipital bone is developed. The malformation might be compared, therefore, with the deficiency in the neural arches of the spinal column, occasioning a spina bifida. The two large openings in the parietal bones were of a different nature: they were not congenital deficiencies in the middle line; they did not occur along the line of junction of spicula—proceeding from ossific centres orginally distinct, but were placed laterally, and each was situated between the eminence which seemed to be the centre of ossification for the parietal bone in which it occurred, and the middle line. The openings, indeed, occupied the position of the parietal foramina, but were many times larger than those apertures are in a normal skull. The possibility of these being greatly exaggerated vascular foramina was then discussed, the cribriform condition of the membrane closing them over, and the relations of the grooves for the venous sinuses internally, seemed to favour such a conclusion. Abnormalities in the construction of the bones of the skull-cap, *i.e.* of the bones developed in membrane, are apparently more frequent than those of the basis cranii, which are developed in cartilage. This is probably due to the circumstance, that the areas of the different bones are less precisely defined, and

that the process of ossification is more liable to disturbance in the former than the latter. The modifications in arrangement are especially apt to occur along the lines of apposition of adjacent osseous areas, *i.e.*, along sutural lines, or along the margins of junction of the subdivisions of a bone proceeding from distinct centres; and in these localities it is that the anatomist so frequently meets with Wormian or triquetral bones, or occasionally with a beak projecting from one bone into an adjacent one, or with the not unfrequent blending of one bone with another along the sutural lines.

5. On Saturated Vapours. By W. J. Macquorn Rankine, C.E., LL.D., F.R.SS. Lond. and Edin., &c.

As this paper consists almost wholly of formulæ, calculations, and tables, it is not suited for being read to a meeting; and therefore the following short abstract of its contents is alone offered for the purpose of being read aloud:—

In the "Edinburgh Philosophical Journal" for July 1849, the author proposed the following formula for the pressure of saturated vapour corresponding to a given boiling point:—

$$\log p = \mathrm{A} - \frac{\mathrm{B}}{t} - \frac{\mathrm{C}}{t^2};$$

where t is the *absolute temperature*, reckoned from the *absolute zero;* and A, B, and C are three specific constants, to be determined from at least three experiments on each substance; and he showed that the results of that formula agreed better with experiment than those of any other formula containing three constants only. In a series of papers on the Mechanical Action of Heat, read to the Royal Society of Edinburgh in 1850, and subsequent years, and in other publications also, the same formula is explained, and its use exemplified in various ways. The first division of the present paper gives the results of the computation of the values of the constants A, B, and C for several fluids for which they had not been previously computed, the data being taken from the second volume of M. Regnault's "Rélation des Expériences, &c.," published in

1862; and it is also shown that by the formula a conclusion was anticipated, which M. Regnault has deduced from his experiments, viz., that "*the elastic force of a vapour does not increase indefinitely with the temperature, but converges towards a limit which it cannot exceed.*" ("Rélation des Expériences," vol. ii. page 647.)

The second division of the paper is occupied chiefly with a comparison between the actual values of the pressures of saturation of the vapours of various fluids, and the values which those pressures would have if the vapours were perfectly gaseous. In the first of the papers already referred to, read to the Royal Society of Edinburgh, and published in their Transactions in 1850, the author proved from the principles of thermodynamics that the "*total heat*" of evaporation of a perfectly gaseous vapour must be represented in dynamical units by the expression

$$\mathrm{J}b + \mathrm{J}c't,$$

where b is a constant to be found by experiment, c' the specific heat of the vapour at constant pressure, and J the dynamical equivalent of an unit of heat, t being the absolute temperature as before. In a paper read to the Royal Society of Edinburgh in 1855, but not published, the same formula was shown to express, in dynamical units, the *total heat of gasefication* of any substance under any constant pressure, when the final absolute temperature is t. In the present paper the author equates that expression to another expression for the total heat of evaporation, from the absolute zero, at a given absolute temperature t, as follows:—

$$\mathrm{J}b+\mathrm{J}c't=\mathrm{J}\int_0 c''dt+t\,\frac{dp}{dt}\,(v-v'');$$

in which v and v'' are the volumes of unity of weight of the substance in the gaseous and liquid states respectively, under the pressure p, and at the absolute temperature t. Then putting for v its value in the perfectly gaseous state—namely,

$$v=\frac{\mathrm{J}(c'-c)t}{p},$$

where c is the specific heat of the gas at constant volume, and neglecting v'' as very small in comparison with v, there is found, by integration, the following value of the hyperbolic logarithm of the

pressure of saturation (a being a constant to be deduced from one experiment for each fluid):—

$$\text{hyp. log } p = a - \frac{b}{(c' - c)} + \frac{c'}{c' - c} \text{ hyp. log } t$$

$$- \frac{1}{c' - c} \int_0^t \frac{d}{t^2} \int_0^t c'' dt \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (\text{A})$$

When c'' is constant (as is approximately the case in some instances) the preceding equation becomes

$$\text{hyp. log } p = a - \frac{b}{(c' - c) t} - \frac{c'' - c'}{c' - c} \text{ hyp. log } t \quad . \quad (\text{B.})$$

The pressures of various vapours, as calculated on the supposition of their being perfectly gaseous by means of the preceding equations, are compared with their actual pressures; the general result being, that when the vapours are rare, the differences are small, and that when the densities increase, the differences increase. For example, in the case of steam, the pressures calculated by equation B agree very closely with the actual pressures from 0° to 160° Cent.; but above the latter temperature the difference gradually becomes considerable, and at 220° Cent. is about one-fiftieth part of the whole pressure. At 0° Cent. 1 pound of saturated steam occupies 3400 cubic feet; at 160° Cent. about 5 cubic feet; and at 228° Cent. about 1·4 cubic foot.

The author also makes some comparisons between the actual volumes of saturated vapours at given boiling-points, and the calculated volumes which they would fill if they were perfectly gaseous; and also between the actual latent heat of evaporation, and the calculated latent heat of perfect gasefication. The general results are in accordance with what is already known,—viz., that the actual volumes of vapours are less than those corresponding to the perfectly gaseous state, and the actual latent heat of evaporation less than the latent heat of gasefication; and the author further points out that the differences in the case of steam increase nearly as the absolute temperature.

6. On the Ganglia and Nerves of the Heart, and their connection with the Cerebro-Spinal and Sympathetic Systems in Mammalia. By James Bell Pettigrew, M.D., Edinburgh, Assistant in the Museum of the Royal College of Surgeons of England.

The Memoir, of which the subjoined is an abstract, is based upon seventy dissections, and is intended as a contribution to our knowledge of the arrangement of the cardiac nerves in the mammalia.

It has the five following objects in view :—

1*st*. To describe the parts of the sympathetic and vagus, which furnish branches to the heart.

2*d*. To trace the branches given off by the sympathetic and vagus, till they disappear in the great cardiac plexuses.

3*d*. To unravel the plexuses, so as to show the manner in which they are formed, and how they resolve themselves.

4*th*. To point out the arrangement of the nerves on the pulmonary artery and aorta, and on the surface and in the substance of the auricles and ventricles.

5*th*. To demonstrate the existence of certain nervous enlargements on the surface and in the substance of the heart generally, and to show that these enlargements are true ganglia, and contain innumerable unipolar and bipolar nerve-cells.

In the first part of the investigation, the cardiac branches furnished by the sympathetic and vagus have been examined in the cat, calf, and rabbit, and also in man; but the author is indebted for his results chiefly to the three former, the nervous system of the domestic animals being, in his opinion, especially interesting, as the animals themselves are admirably adapted for the purposes of vivisection.

The chief points of difference to be noted in the cardiac nerves of the animals referred to, occur in the sympathetic, and are as follows :—

In the cat, the cardiac nerves furnished by the sympathetic pro-

ceed from two large solitary ganglia, one of which is situated at the root of the neck on the right side, the other on the left.

In the rabbit, they proceed from four smaller ganglia, two of which are situated on the right side of the root of the neck, the remaining two on the left.

In the calf, the number of ganglia furnishing cardiac branches increase to six, these being similarly divided and situated.

The cat, therefore, seems best adapted for physiological pursuits, and a series of carefully performed experiments on that animal may probably be the means of determining the nature and the extent of the influence exerted by the nerves on the movements of the heart, if indeed these movements, as the author remarks, are not referable to the ganglia situated in the heart itself, which, from various considerations, he thinks not unlikely. The heart, *e. g.*, is known to contract and dilate for a considerable period after the blood, which is regarded as its natural stimulus, is abstracted from it. It further acts regularly when removed from the body and placed under a bell jar from which the air has been subsequently exhausted by the action of an air-pump. In the frog, moreover, as not unfrequently happens, the heart suddenly ceases to contract, if the base, where the ganglia are most numerous, be removed by the stroke of a scissors.*

In the second part of the investigation, the great cardiac plexuses are shown to resolve themselves into four minor ones.

Of these, one occurs on the pulmonary artery, and supplies branches to that surface of the auricles which is directed towards the great vessels. It also supplies branches to the right ventricle. A second occurs between the pulmonary artery and aorta, and furnishes branches to the anterior coronary vessels, and to the right and left ventricles, particularly the latter. A third occurs on the posterior coronary sinus, and gives branches to the left auricle and ventricle, especially the latter. The fourth occupies that surface of the auricles which is directed towards and is in contact with the pericardium, and supplies branches to the inferior cava, to the auricles, and to the posterior surface of the right ventricle. The

* Brachet declares that if the cardiac plexus in mammals be destroyed the movements of the heart are suddenly and permanently arrested.—*Du Système Nerveuse Ganglionaire*, p. 120.

four minor plexuses referred to supply branches which pursue a definite direction. Thus the branches from the plexus, situated between the pulmonary artery and aorta, and between the former and the right auricle, proceed in a spiral direction from right to left downwards, so that they cross the muscular fibres composing the ventricles. The same may be said of the branches proceeding from the plexuses occurring on the posterior surface of the auricles and on the posterior coronary sinus. By this arrangement the nerves distributed to the heart are brought into intimate contact not only with the muscular fibres, but also with the blood-vessels; and this is important, as it is on the latter that the ganglia are most frequently detected.

In the third and concluding part of the investigation, the enlargements and fusiform swellings figured by Scarpa* and Lee† have been examined microscopically, and their precise nature ascertained. The hearts examined for this purpose were numerous, and consisted, among others, of those of man, the horse, ox, camel, heifer, dog, panther, deer, seal, and pig.

The ganglia occur as irregularly shaped enlargements, having three, four, five or more nerves connected with them. Sometimes they appear as simple dilatations occurring on the nerves as they cross the vessels. They are most numerous on the posterior coronary sinus, where they form a continuous network not hitherto described; but they are also to be found in large quantities on the vessels and throughout the substance of the heart generally.

When a ganglion, with several nerves proceeding from it, is detached and treated with carmine and glycerine, it is found, on microscopic examination, to be crowded with nerve-cells, the poles of which are directed towards the nerves themselves. When one of the swellings or dilatations which occur on the nerves, as they cross the vessels, is similarly treated, the nerve-cells are seen to form an oval patch corresponding in shape with the dilatation, and the poles of the cells are directed, as a rule, in the direction of the nerve trunk. In some instances the nerves terminate in bulbous expansions, and on such occasions the expansions in question are crowded with nerve-cells, the poles of which are directed towards the attached

* Tabulæ Neurologicæ, fol. 1794.

† Phil. Trans., 1849.

nerve. It is not uncommon to observe one of these terminal expansions, with a smaller one, apparently in process of formation, attached to it.

The nerves and nerve-plexuses, in their various combinations, and the ganglia and their contents, have been described at length, and the appearances presented by them carefully figured.

Note to Paper on the Action of Hydriodic Acid on Mandelic Acid, by Dr A. C. Brown. Read March 20, 1865.

June 6, 1865.

Since this paper was printed I have prepared the aldehyd of alpha-toluic acid. I shall only mention here that it possesses in a very high degree the smell of honey, which was observed in the case of the alpha-toluic acid described in the paper; and that it is probable that that acid contained traces of the aldehyd to which it owed not only its smell, but also the excess of carbon and hydrogen indicated by the analyses.

The following Donations to the Library were laid on the table:—

Der Zoologische Carten. Zeitschrift fur Beobachtung Pflege und Zucht der Thiere. Herausgegeben von Prof. Dr C. Bruch. Jahrg. V. Nos. 2–12. Frankfurt, 1864. 8vo.—*From Prof. Bruch.*

Sitzungsberichte der Konigl. Bayer. Akademie der Wissenschaften zu Munchen. II., Heft 3–4. Munchen, 1864. 8vo.—*From the Academy.*

Monatsberichte der Koniglichen Preuss. Akademie der Wissenschaften zu Berlin. aus dem Jahre 1864. Berlin, 1865. 8vo.—*From the Academy.*

Haematologische Studien von Dr Alexander Schmidt. Dorpat, 1865. 8vo.—*From the Author.*

The Sewage of the Metropolis. A Letter to John Thwaites, Esq. London, 1865. 8vo.—*From G. Robertson, Esq., C.E.*

Proceedings of the British Meteorological Society. Vol. II., No. 18. London, 1865. 8vo.—*From the Society.*

Proceedings of the Royal Horticultural Society. Vol. V., No. 4. London, 1865. 8vo.—*From the Society.*

Proceedings of the Royal Medical and Chirurgical Society of London. Vol. V., No. I. 8vo.—*From the Society.*

The Power of Form applied to Geometric Tracery. By Robert William Billings, Esq. Edinburgh, 1851. 8vo.—*From the Author.*

Notes on the South Slavonic Countries in Austria and Turkey in Europe. Edited, with a Preface, by Humphry Sandwith, C.B., D.C.L. Edinburgh, 1865. 8vo.—*From the Editor.*

Monthly Notices of the Royal Astronomical Society. Vol. XXV., No. 5. London, 1865. 8vo.—*From the Society.*

Societá reale di Napoli, Rendiconto delle Tornate e dei Lavori dell' Accademia di Scienze Morali e Politiche. Anno quarto. Napoli, 1865. 8vo.—*From the Society.*

Monday, 6th March 1865.

Monday, 20th March 1865.

Monday, 3d April 1865.

PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

SESSION 1865–66.

CONTENTS.

Monday, 4th December 1865.

[Turn over.

[*For continuation of Contents, see pp. 3 and 4 of Cover.*